

ORTHODONTIST AND GENERAL PRACTITIONER PERCEPTIONS OF
INVISALIGN® TREATMENT OUTCOMES

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ABSTRACT

Objectives: Little is known about the treatment standards and expectations of Invisalign treatment outcomes between orthodontists and general practitioners (GP). The objective of this qualitative research project was to explore how orthodontists and GPs perceive Invisalign treatment outcomes, and to determine which criteria they use to judge successful treatment.

Methods: Open-ended interviews were conducted with three orthodontists and two GPs. These interviews were recorded, transcribed, coded and analyzed by the conventional phenomenological qualitative research protocol. Each clinician selected four Invisalign cases that they treated and perceived as successful outcomes. To augment qualitative methods, quantitative data were generated to determine pre-treatment Discrepancy Index (DI) and post-treatment Objective Grading System (OGS) scores as calculated by OrthoCAD software.

Results: Independent sample T-tests showed no significant difference in total DI score ($p=0.287$) and total OGS score ($p=0.840$) between the orthodontist ($n=12$) and GP ($n=7$) cases. Orthodontists perceive incisor torque and smile esthetics as important criteria for successful Invisalign outcomes. In contrast, GPs do not. Orthodontists and GPs unanimously perceive that Class I occlusion is an important criterion for successful treatment. GPs perceive extraction cases as a challenge to obtain successful outcome with Invisalign whereas, orthodontists do not.

Conclusions: Differences exist between orthodontist and GP perceptions of what constitutes successful Invisalign treatment. Currently employed standards of excellence can be found in a wide spectrum of finishes; however, they are incapable of defining the excellence of finish. Selective standards differentiate the GPs from orthodontists, but agreement exists for ambition to finish in Class I occlusion. Esthetics and torque are valued higher by the orthodontists than are by the GPs. The utility of current standards-of-care need to be questioned and redefined.

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CHAPTER 1

INTRODUCTION

In 1997, Align Technology introduced the Invisalign system. This appliance system combines principles of orthodontic tooth movement with 3D software technology (Tuncay, 2006). Over 6 million patients have been treated with Invisalign since its inception. Demand continues to increase as patients prefer the superior esthetics and comfort of clear aligners over traditional fixed appliances (Gu, 2017). Orthodontists and general practitioners (GPs) commonly use Invisalign to treat orthodontic cases. An estimated 20 to 50 percent of all orthodontic treatment is performed by GPs. Furthermore, eight percent of GPs treat patients with clear aligner systems such as Invisalign (Elizabeth, 2017). Use of the Invisalign system simply requires any dental provider to complete a one-day certification course. Despite its widespread use, little is known about the “expectations” of treatment outcomes between these two groups of clinicians. It remains unclear whether or not Invisalign can perform equally well for both orthodontists and GPs.

It has been reported that a level of agreement between orthodontists and GPs exists in evaluations of orthodontic treatment need. It is also shown that orthodontists judge malocclusions more critically than do GPs (Julian-Castellote, 2016). Researchers in a 2017 study sought to identify differences in esthetic smile perception among orthodontists and GPs. They found that orthodontists and GPs do not judge all smile parameters the same. For example, orthodontists had a lower threshold of acceptance for midline deviations, but were more sensitive to variation in buccal corridors compared to

GPs (Sadraghi, 2017). In a 2017 study, Best et al. evaluated differences in treatment management between orthodontists and GPs that used clear aligner therapy. Despite the greater experience of orthodontists with this treatment modality, GPs were more confident in treating more complex malocclusions. GPs were also found to spend less time on the patients' digital treatment plans and used fewer auxiliaries during treatment (Best, 2017). Perhaps the results suggest that differences exist in treatment goals and expected outcomes between these clinician groups. Although these studies revealed potential differences between these two clinician groups, perceptions of treatment outcome between them remain equivocal (Berk, 2002).

Currently, there are a number of grading systems proposed to objectively assess treatment outcomes. The American Board of Orthodontics (ABO) has adopted the Objective Grading System (OGS) as a way to fairly assess final orthodontic treatment results (Casko, 1998). Previous studies have used the OGS to compare outcomes between cases treated with Invisalign to traditional fixed appliances (Djeu, 2005; Kim, 2007; Li, 2015; Gu, 2017). Despite such numerous reports, there is a paucity of studies that objectively compare Invisalign outcomes in the hands of orthodontists and GPs. To shed light on this uncertainty will help discern the perceptions of efficacy of Invisalign treatment among different dental professionals. Simply put, when do clinicians call a treatment satisfactorily “done” and are there disparities in this judgment between the GP and orthodontist clinicians? It is our desire to determine how clinicians perceive treatment outcomes that result from this appliance system.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Details of the Discrepancy Index

The ABO currently uses the Discrepancy Index (DI) to objectively evaluate case complexity. The DI uses measurements taken from pretreatment orthodontic records including casts, cephalometric radiographs, and panoramic radiographs. The DI summarizes the clinical features of a patient's condition. It uses an objective list of conditions that represents several common problems related to an orthodontic diagnosis. It was the hope of the ABO that this measurement of case complexity would lead to better understanding of case difficulty. The ABO recognized that a direct measurement of difficulty is both elusive and unrealistic. To some degree, it is intrinsically subjective and a matter of perception. Some conditions may be considered by some clinicians as easy to treat whereas others may view those same conditions as difficult. Variations in overall treatment approach, appliance use, or training may contribute to these differences (Cangialosi, 2004).

The DI was initially developed by the ABO in 1998. The initial pilot study took place in 1999. It was modified and underwent a series of field tests from 2000 to 2003 (Cangialosi, 2004). The DI was most recently updated by the ABO in 2016. Measurements for the DI are made with casts properly trimmed to ABO standards and placed in occlusion. Model occlusion is determined by placing the casts on their base on a flat surface. They are then brought together into maximum intercuspation (ABO Discrepancy Index, 2016).

The components that comprise the DI include measurements of overjet, overbite, anterior open bite, lateral open bite, crowding, occlusion, lingual posterior crossbite, and buccal posterior crossbite. A cephalometric radiograph is used to measure the ANB angle, SN-MP angle, and incisor to mandibular plane angle (IMPA). Additional treatment complexities may be scored under a category designated "Other". This may include the presence of supernumerary teeth, ankylosis of permanent teeth, anomalous morphology, impaction, midline discrepancy, missing teeth, spacing, tooth transposition, skeletal asymmetry, and any additional treatment complexities (ABO Discrepancy Index, 2016). These categories were chosen because they represent most conditions that are treated orthodontically and could be related to deviations from accepted norms (Cangialosi, 2004).

Overjet is measured from the most facial surface of the most lingual mandibular incisor to the middle of the incisal edge of the most facially positioned maxillary incisor. For an overjet of zero (edge-to-edge), one point is scored; for 1 to 3 mm, no points are scored; for 3.1 to 5 mm, two points are scored; for 5.1 to 7 mm, three points are scored; for 7.1 to 9 mm, four points are scored, for greater than 9 mm, five points are scored. Negative overjet (anterior crossbite) is measured from the facial surface of the maxillary tooth to the middle of the incisal edge of the mandibular tooth. The score is marked as one point per millimeter for each anterior tooth in crossbite (ABO Discrepancy Index, 2016).

Overbite is measured between the two antagonistic anterior teeth with the greatest vertical overlap. For an overbite up to 3 mm, no points are scored; for 3.1 to 5 mm, two points are scored; for 5.1 to 7 mm, three points are scored. If there is 100 percent overbite

or if any of the mandibular incisors are impinging on the palatal tissues, then five points are scored (ABO Discrepancy Index, 2016).

For anterior open bite, each anterior tooth (canine to canine) in an edge-to-edge relationship scores one point per tooth. For each anterior tooth with greater than 1 mm of open bite, one point per millimeter per involved maxillary tooth is scored. No points are scored for any teeth that are blocked out of the arch due to space deficiency or that are not fully erupted (ABO Discrepancy Index, 2016).

A lateral open bite is measured for maxillary teeth from first premolar to second molar. A tooth is scored if it is in an open bite relationship greater than 0.5 mm from its opposing tooth, measured from cusp to cusp. A score of two points for each millimeter of open bite is given for each maxillary tooth involved. No points are given for any teeth that are blocked out of the arch due to space deficiency or that are not fully erupted (ABO Discrepancy Index, 2016).

Crowding is measured from the mesial contact of the left first molar to the mesial contact of the right first molar in the most crowded arch. For crowding less than 1 mm, no points are scored; for 1.1 to 3 mm, one point is scored; for 3.1 to 5 mm, two points are scored; for 5.1 to 7 mm, four points are scored; for greater than 7 mm, seven points are scored (ABO Discrepancy Index, 2016).

Occlusion is based on the Angle molar classification. Each side is scored individually. No points are given for a Class I relationship in which the mesiobuccal cusp of the maxillary first molar occludes with the buccal groove of the mandibular first molar. Two points are given for an end-on Class II or Class III relationship. Four points are given for a full cusp Class II or Class III relationship. If the relationship is beyond

Class II or Class III, then one additional point per millimeter is given (ABO Discrepancy Index, 2016).

Lingual posterior crossbite is measured for maxillary teeth from first premolar to second molar. For each maxillary tooth where the maxillary buccal cusp is greater than 0 mm lingual to the buccal cusp tip of the opposing tooth, one point is scored (ABO Discrepancy Index, 2016).

Buccal posterior crossbite is measured for maxillary teeth from first premolar to second molar. For each maxillary tooth where the maxillary palatal cusp is greater than 0 mm buccal to the buccal cusp of the opposing tooth, two points are scored (ABO Discrepancy Index, 2016).

Cephalometric radiograph measurements include the ANB angle, SN-MP angle, and IMPA. For ANB angles greater than or equal to 6° or less than or equal to -2° , four points are scored. An additional point is scored for each full degree greater than 6° or less than -2° . For an SN-MP angle greater than or equal to 38° or less than or equal to 26° , two points are scored. An additional two points are scored for each full degree greater than 38° . An additional point is scored for each full degree less than 26° . For IMPA greater than or equal to 99° , one point is scored. For each full degree greater than 99° , an additional point is scored (ABO Discrepancy Index, 2016).

Other conditions adding to treatment complexity are given the following point values: one point per supernumerary tooth, two points per ankylosed permanent tooth, two points per tooth with anomalous morphology of tooth size or shape, two points per impacted tooth (excluding third molars), one point per non-congenitally missing tooth, two points per congenitally missing tooth (excluding third molars), two points for a

midline discrepancy greater than or equal to 3 mm, two points for a maxillary diastema of 2 mm or greater, two points per arch for spacing of four or more teeth, two points per each tooth transposition event, and three points for skeletal asymmetry treated non-surgically (ABO Discrepancy Index, 2016).

Additional treatment complexities receive two points. Examples of additional treatment complexities include the following: significant Bolton discrepancy (3 mm or greater), severe enamel wear, multiple areas of shortened roots, deep curve of Spee, traumatic injury to multiple teeth, periodontally labile condition, severely angulated roots, severe bi-maxillary protrusion, cleft lip and palate, or craniofacial dysmorphologies (ABO Discrepancy Index, 2016).

2.2 Details of the Objective Grading System

In 1994, the ABO sought to make the orthodontic clinical board examination more objective. The goal was to establish a fair and objective scoring system to evaluate treatment outcomes. This scoring system was to have high reliability and validity. Through a series of four field tests over five years, the ABO established the OGS. The OGS assesses the occlusal and radiographic results of orthodontic treatment. Since 1999, the OGS has been used by examiners to grade the clinical portion of the ABO board examination (Casko, 1998).

Data from the pilot 1995 OGS field test indicated that 85 percent of the inadequacies in the final results occurred in 7 of the 15 criteria assessed. These criteria included alignment, marginal ridges, buccolingual inclination, overjet, occlusal relationships, occlusal contacts, and root angulation. Subsequent field tests continued to

confirm that the majority of inadequacies in final results occur in these same seven criteria. In the 1997 field test, the ABO introduced a special instrument to measure the casts. The ABO measuring gauge allowed the criteria to be measured more accurately and with increased reliability. The ABO also added the criterion of interproximal contacts. This raised the total number of OGS criteria to eight. The 1997 and 1998 field tests were used to establish a passing score. Points are scored for each criteria when the relationships are less than ideal. A case that scores 30 or higher will fail. A case that scores under 20 will usually pass (Casko, 1998).

Alignment was established as a criterion because it is usually one of the main objectives of any orthodontic treatment plan. In the anterior region, the incisal edges and lingual surfaces of the maxillary anterior teeth and the incisal edges and labial-incisal edges of mandibular anterior teeth are used. These surfaces were chosen because they are the functioning surfaces of these teeth and they affect esthetics if not properly aligned. In the maxillary posterior region, the central grooves of the premolar and molar teeth are used. In the mandibular posterior region, the buccal cusps of the premolar and molar teeth are used. These surfaces were chosen because they are easily identifiable and are the functioning surfaces of those teeth. The most commonly malaligned teeth were the maxillary and mandibular lateral incisors and second molars. For teeth that deviate less than 0.5 mm from proper alignment, no points are given. For teeth that deviate 0.5 to 1 mm, one point is given. For teeth that deviate greater than 1 mm, two points are given (Casko, 1998).

Marginal ridges are used to assess proper vertical position of posterior teeth. The marginal ridges should be at the same level in an ideal dentition. This results in a flat

bone level between adjacent teeth in a periodontally healthy individual. Proper marginal ridge level also helps establish proper occlusal contacts. The most common marginal ridge discrepancy occurs between the maxillary first and second molars (Casko, 1998). For OGS scoring, the canine-first premolar contact is not included. The distal contact of the mandibular first premolar is also not included. For all posterior teeth, marginal ridge discrepancies less than 0.5 mm score no points. Discrepancies 0.5 to 1 mm score one point. Discrepancies greater than 1 mm score two points (ABO Model Grading System, 2012).

Buccolingual inclination is used to evaluate the buccolingual angulation of posterior teeth. A significant difference in height between the buccal and lingual cusps of maxillary and mandibular posterior teeth should not exist. Proper buccolingual inclination helps establish proper occlusion and avoids balancing interferences (Casko, 1998). The ABO gauge is used to measure buccolingual inclination. The straight edge surface lies flat on the occlusal surface of left and right posterior teeth. The buccal cusps of contralateral mandibular posterior teeth should touch the straight edge. The lingual cusps should be within 1 mm of the straight edge. The palatal cusps of contralateral maxillary posterior teeth should contact the straight edge. Buccal cusps should be within 1 mm of the straight edge. The mandibular first premolars and distal cusps of second molars are not scored. Deviations less than 1 mm score no points. Deviations of 1 to 2 mm score one point per tooth. Deviations greater than 2 mm score two points per tooth (ABO Model Grading System, 2012).

Occlusal relationship is used to evaluate the anteroposterior position of maxillary and mandibular posterior teeth. Angle's relationship is used to score this criterion. The

maxillary canine cusp tip and buccal cusp tips of maxillary premolars must align within 1 mm of the opposing interproximal embrasures. The mesiobuccal cusp of the maxillary first molar must align within 1 mm of the buccal groove of the mandibular first molar (Casko, 1998). For each maxillary tooth from canine to second molar, deviations less than 1 mm score no points. Deviations of 1 to 2 mm score one point per tooth. Deviations greater than 2 mm score two points per tooth (ABO Model Grading System, 2012).

Occlusal contacts are measured to evaluate the acceptability of posterior occlusion. A primary objective of orthodontic treatment is to establish maximum intercuspation of opposing teeth. The buccal cusps of mandibular premolars and molars and palatal cusps of maxillary premolars and molars are used to measure this criterion. These surfaces were selected because they are the functioning cusps of those teeth (Casko, 1998). Undersized cusps are not scored. If cusps are in contact with the opposing arch, no points are scored. If a cusp is out of contact and the distance is 1 mm or less, one point is scored. If a cusp is out of contact and the distance is greater than 1 mm, two points are scored (ABO Model Grading System, 2012).

Overjet evaluates the transverse relationship of posterior teeth and the anteroposterior relationship of anterior teeth (Casko, 1998). In the posterior region, the mandibular buccal cusps should contact the center of the occlusal surfaces, buccolingually, of the opposing maxillary teeth. In the anterior region, the mandibular canines and incisors should contact the palatal surfaces of maxillary anterior teeth. If this relationship exists, no points are scored. If the mandibular buccal cusp deviates 1 mm or less from the center of the opposing tooth, one point is scored. If it deviates more than 1 mm, two points are scored. If the mandibular canines or incisors are not contacting the

opposing maxillary tooth and the distance is 1 mm or less, one point is scored per tooth. If the distance is greater than 1 mm, two points are scored (ABO Model Grading System, 2012).

Interproximal contacts are evaluated to determine if all spaces in the dental arch have been closed. Open spaces are unaesthetic and may lead to food impaction (Casko, 1998). The mesial and distal surfaces of all teeth should be in contact with each other. For interproximal space 0.5 mm or less, no points are scored. For interproximal space greater than 0.5 mm to 1mm, one point is scored. For interproximal space greater than 1 mm, two points are scored (ABO Model Grading System, 2012).

Root angulation is used to determine how well the teeth have been positioned relative to each other. Properly angulated roots have sufficient bone between them. This could be beneficial to a patient susceptible to periodontal disease (Casko, 1998). A panoramic radiograph is used to evaluate root angulation. Canine teeth and teeth with dilacerated roots are not scored. Ideally, roots should be parallel to each other and perpendicular to the occlusal plane. No points are scored if this relationship exists. If a root is angulated mesially or distally and is not touching the adjacent root, one point is scored. If a root is angulated mesially or distally and is touching the adjacent root, two points are scored (ABO Model Grading System, 2012).

2.3 Outcome Comparison of The Invisalign System to Fixed Appliances

The turn of the twenty first century marked the birth of the Invisalign appliance system. Over six million patients have been treated with Invisalign since its introduction to the orthodontic market. In 2005, Djeu et al. became the first group of researchers to

objectively compare Invisalign treatment with traditional fixed appliances. Post-treatment records from 48 Invisalign patients and 48 fixed appliances patients were evaluated with the OGS and compared. The data show that the Invisalign group scored on average 13 points higher than the fixed appliances group. The OGS passing rate for the Invisalign group was 27% lower than the passing rate for the fixed appliances group. The researchers concluded that Invisalign did not treat malocclusions as well as fixed appliances (Djeu, 2005).

It should be noted that the patients in the Invisalign group were among the orthodontist's first patients to complete treatment with the Invisalign appliance. On the contrary, the orthodontist had decades of experience using fixed appliances. The researchers even admitted that, "treatment outcome is only as good as the operator's proficiency, no matter what appliance is used" (Djeu, 2005). The fixed appliances group may have had an advantage over those in the Invisalign group because of differences in the orthodontist's experience with Invisalign compared to fixed appliances.

In a 2007 study at Temple University, Kim looked to shed light on orthodontists' perceptions of Invisalign efficacy. He investigated how well the Invisalign aligners performed compared to clinicians' expectations. Those findings were compared to how well fixed appliances performed to clinicians' expectations. The predicted outcomes and actual outcomes for the Invisalign and fixed appliances groups were measured and compared using the OGS. The participants expected better treatment results for fixed appliances than what was actually achieved. The participants' predicted results closely matched the actual outcomes for moderate and difficult Invisalign cases. The participants expected significantly poorer outcomes than what was actually achieved for simple

Invisalign cases. Overall, Invisalign cases finished at least as good, if not better than what was expected whereas fixed cases finished more poorly than what was expected. For simple and moderate cases, neither Invisalign nor fixed appliances appeared to show any exceptional performance in a particular OGS category. Actual OGS scores for fixed appliances and Invisalign showed no significant difference. Kim had concluded that performance with Invisalign has advanced to a point where simple cases can be finished beyond clinicians' expectations (Kim, 2007).

Align Technology has continued to introduce changes to the Invisalign tray material, attachments, and treatment algorithms since these studies were conducted. After 2008, advancements such as Precision Cuts, Precision Bite Ramps, and Smart Force Attachments have led to more precise tooth movement (Gu, 2017). In a 2017 retrospective case-control study, Gu et al. compared the treatment effectiveness and efficiency of the Invisalign system to conventional fixed appliances. The peer assessment rating (PAR) index was used to evaluate pretreatment and post-treatment records of 48 Invisalign patients and 48 fixed appliances patients. The PAR index is a measure of how much a patient deviates from an ideal occlusion. Similar to the OGS, it objectively and quantitatively evaluates orthodontic treatment outcomes. No statistically significant difference in pretreatment and post treatment PAR scores was found between the Invisalign and fixed appliances groups. The data also indicated that the treatment time for Invisalign patients was on average 5.7 months shorter compared to fixed appliances patients. The researchers concluded that similar to fixed appliances, excellent treatment outcomes can be achieved with Invisalign. The clinicians' knowledge and experience contribute to the quality of treatment outcomes (Gu, 2017). This most recent study helps

support the claim that Invisalign can be used to treat a wide range of cases as effectively as fixed appliances. Perhaps this has contributed to the widespread use of Invisalign by orthodontists and GPs alike.

2.4 Perceptions of Treatment Need and Case Complexity

Perceptions of treatment need are affected by many variables. What these variables are and how they are used by clinicians to determine treatment need is unknown (McGorray, 1999). In a 2002 study, Berk et al. compared perceptions of treatment need between orthodontists, GPs, and pediatric dentists. It was hypothesized that variables such as differences in educational training may lead to disagreement between the groups. In this study, 18 orthodontists, 10 GPs, and 15 pediatric dentists reviewed 137 dental casts. They then stated whether or not orthodontic treatment was needed. A high level of agreement was found between all clinician groups. The clinicians' rationale for treatment need was not assessed. It remains unclear as to why each clinician recommended treatment when they did. Perhaps different parameters were used by each clinician group to determine treatment need. The authors recognized that it is important to understand the perceptions of all dental professionals. Their perceptions may impact the utilization and success of orthodontic treatment (Berk, 2002).

It has been noted that perceptions of malocclusion may vary among individuals. Whereas patients judge results by social and cultural standards of beauty, orthodontists tend to use occlusal parameters. It has been recognized that a disconnect may exist between orthodontists, GPs, and laypersons as to which features may present an orthodontic problem or what may define treatment success (Julian-Catellote, 2006). In

this study, a sample of 150 individuals were split into three groups: 30 GPs, 30 orthodontists, and 90 laypersons. Each group examined frontal smiling photos of 24 patients. They then assessed the esthetics of each occlusion. According to data, orthodontists were most critical of the malocclusions (Julian-Castellote, 2016). Again, each group's rationale for judgment was not explored.

Differences exist in the educational backgrounds of orthodontists and GPs. Orthodontists receive an additional two to three years of education in diagnosis and correction of dental malocclusions and skeletal discrepancies. GPs receive limited training in orthodontic diagnosis and treatment while in dental school. Perceptions of orthodontic treatment need are quite subjective and may vary based on level of dental education. In a 2017 study, Elizabeth et al. assessed the perceptions of orthodontic case complexity among orthodontists, GPs, orthodontic residents, and dental students. They then compared individuals' treatment need perceptions with the DI. Pre-treatment orthodontic records of 29 cases with various DI scores were obtained. A total of 343 orthodontists, GPs, orthodontic residents, and dental students participated in an online survey. The participants were asked to subjectively evaluate the complexity of each case. The data show that the association between case complexity and DI scores varied significantly by group. When the DI score was greater than 15, orthodontists and orthodontic residents perceived cases as more complex compared to the other groups. Orthodontists and orthodontic residents were able to recognize the complexity of a case more effectively than those with no formal orthodontic training. It was therefore concluded that the level of professional education may significantly impact perceptions of case complexity (Elizabeth, 2017).

2.5 Comparisons of Treatment Management

Much remains unknown about orthodontic treatment that is provided by GPs in the United States. To shed light on this, Galbreath et al. conducted a national survey in 2006. The purpose of this survey was to document current trends in orthodontic treatment being provided by GPs and to gain insight into the level of orthodontic training that GPs receive. A total of 462 GPs across the United States responded to the survey. When asked where they received the majority of their orthodontic training, the most common response was "in dental school" (29%). The majority (55%), however, reported that their dental school orthodontic education was poor. Among the GPs surveyed, 80 percent receive no more than 10 hours of orthodontic continuing education annually. The highest percentage of respondents had fewer than 10 orthodontic appointments per week (46%), referred less than five patients per month to an orthodontist (47%), and spent less than 10% of their time providing orthodontic treatment (88%). GPs provided orthodontic treatment for patients in all stages of dental development including the permanent dentition (38%), late mixed dentition (29%), and early mixed dentition (34%). The most common conditions or malocclusions they treated included space maintenance (57%), anterior crossbite (37%), minor rotations (36%), habits (33%), and molar uprighting (33%). The most commonly used orthodontic appliances were removable Hawley appliances with finger springs (36%), straight archwires (24%), fixed rapid palatal expanders (22%), and functional appliances (22%) (Galbreath, 2006). Information about the orthodontic treatment patterns and level of orthodontic training of GPs may provide insight into potential differences in treatment between orthodontists and GPs.

Whether or not GPs have adequate training to effectively provide comprehensive orthodontic treatment remains controversial. Both orthodontists and GPs are able to provide orthodontic treatment with Invisalign following a one day certification course. In a 2010 study, Vicens and Russo compared Invisalign use by orthodontists and GPs. A questionnaire was mailed to orthodontists and GPs. A total of 160 responses were received. It was discovered that there were no differences in the percentage of cases completed, the percentage of cases that finished on time, the percentage of cases with midcourse correction, and the number of ClinChecks without modification from their last 10 cases. Orthodontists started significantly more cases compared to GPs. Immediately after initial Invisalign certification, most GPs and orthodontists were not comfortable to treat patients with Invisalign or to understand how Invisalign works. The responses also indicated that the clinician groups differed in their comfort level for treatment of certain case types. They found that 89 percent of orthodontists would treat a large diastema with Invisalign compared to only 61 percent of GPs. The data indicated that at a beginner level, most GPs would use Invisalign to treat a Class II subdivision with a deep bite whereas most orthodontists would not. This difference may be due to a difference in treatment goals. Perhaps the GPs did not have Class I correction as a goal. Most orthodontists and GPs agreed that mild Class I malocclusions were good cases to treat by less experienced Invisalign providers (Vicens, 2010).

It is known that Invisalign is able to correct some malocclusions very successfully whereas it may not be as effective for others. Therefore proper case selection is crucial when clinicians choose to provide orthodontic treatment with Invisalign. Authors of a recent study investigated differences in case selection, treatment management, and

aligner treatment expertise between orthodontists and GPs (Best, 2017). In this study, 374 orthodontists and 229 GPs responded to a survey. Orthodontists treated significantly more Invisalign cases and received more Invisalign training compared to GPs. The survey asked orthodontists and GPs how confident they felt to treat different cases to an ideal occlusion. The data indicated significant differences in Invisalign case selection confidence between orthodontists and GPs. GPs were significantly more confident than orthodontists in treating deep bites, severe crowding, and Class II malocclusions. Clinicians were also asked information about their typical protocols for treating patients with Invisalign, including elastic use, interproximal reduction, and refinement use. Orthodontists and GPs showed no significant difference in the use of interproximal reduction. Significant differences in the use of other auxiliaries did exist. Orthodontists were significantly more likely to use elastics, prescribe extractions, and use a combination of fixed appliances and aligners. Orthodontists were also significantly more likely to spend a longer time reviewing the ClinCheck and were more likely to do refinements (Best, 2017). These differences may be due to dissimilarities in treatment goals. Perhaps GPs are focused only on alignment of anterior teeth whereas orthodontists may be focused on both occlusion and alignment of the complete dentition. It was concluded that GPs were more confident to treat more complex malocclusions with Invisalign, spend less time on the patients' digital treatment plan, and use fewer auxiliaries during treatment. These findings may demonstrate a difference in treatment goals (Best, 2017).

2.6 Comparisons of Treatment Outcomes

At the start of the twentieth century, orthodontics emerged as the first dental specialty. It was through the leadership of Edward H. Angle, regarded as the "Father of Modern Orthodontics," that orthodontics distinguished itself (Asbell, 1990).

Specialization in orthodontics requires at least 2700 curricular hours of education over a minimum 24 month period at an accredited orthodontic residency program (Abei, 2004).

Throughout its history as a specialty, orthodontists continue to assert that orthodontic specialists provide better orthodontic treatment than do other dental practitioners. For a long time, little quantitative evidence existed to objectively support this claim.

In 2004, Abei et al., compared orthodontic treatment outcomes between patients treated by orthodontists and those treated by GPs. All cases were treated from 1997 to 1998 using traditional fixed appliances. A total of 126 cases treated by orthodontists were compared to 70 cases treated by GPs. The OGS was used to assess final treatment outcomes. Data show that the OGS scores were significantly lower for patients treated by orthodontists compared to patients treated by GPs. This indicates superior outcomes in the orthodontist group. The greatest difference occurred in the alignment score where the orthodontist group scored better. Patient perception of smile improvement was also assessed in this study. No significant difference was found between the two groups. Data indicated that patients did not see any differences in the outcomes of treatment based on dental practitioner. It was concluded that although treatment in the hands of orthodontists objectively provides better results, patients cannot discern the difference (Abei, 2004).

In a 2012 study, researchers evaluated the quality of orthodontic treatment provided by orthodontists and GPs (Marques, 2012). In this blind study, 60 orthodontic

cases treated with traditional fixed appliances were evaluated using the OGS. A total of 30 cases treated by orthodontists were compared to 30 cases treated by GPs. Data indicated that 29 orthodontists (96.7%) presented cases that were satisfactory and would pass the ABO board examination. Only 15 GPs (50%) presented cases that were satisfactory and passing. The results further indicated that orthodontists achieved better outcomes for all OGS criteria measured. One exception was for buccolingual inclination in which no statistically significant difference was observed. Pre-treatment comparison revealed that the orthodontists and GPs selected cases with similar initial case complexity. In addition to producing better results, treatment time was on average five months shorter when treated by an orthodontist (Marques, 2012). This study provides additional evidence that orthodontic treatment by orthodontists and GPs results in different outcomes.

At the conclusion of treatment, it is beneficial for clinicians to assess treatment outcomes. This may help to establish future treatment goals, set standards, learn from past mistakes, and determine efficient methods for future treatments. These studies provide needed insight into the quality of orthodontic treatment performed by orthodontists and GPs. To date, no such studies have been performed that compare treatment outcomes between orthodontists and GPs with the Invisalign system. It remains unknown whether or not differences in Invisalign treatment outcomes exist between orthodontists and GPs.

2.7 Qualitative (Phenomenological) Research Method

The scientific literature is overshadowed by quantitative research. This modality relies on the statistical analysis of data to make comparisons. Unlike quantitative research, qualitative research findings are not derived from statistics (Strauss, 1998). The analysis of qualitative data is non-mathematical and requires careful interpretation. Data are often acquired through interviews and observations. The purpose of this research modality is to describe persons' lives, experiences, behaviors, emotions, or feelings. It may be used to discover new concepts and relationships and to help form a theoretical explanation (Strauss, 1998). Such methods may be used to explore areas about which little is known (Strauss, 1998).

There are three major components of qualitative research. Data comprise the first component. It is commonly obtained through interviews. The next component involves the interpretation and organization of data. This process involves coding in which data are analyzed, consolidated, and related to one another so that comparisons can be made. The third component is the presentation of data (Strauss, 1998).

Grounded theory is one approach to qualitative research. Grounded theory offers insight and provides a direction for further study. The researcher does not begin with a pre-conceived theory. Rather, the theory arises from analyzed data (Strauss, 1998). A theory is ultimately developed that allows the researcher to better understand the experiences of a particular group of people. It requires transcribed interviews to be carefully studied sentence by sentence. Words or phrases are coded, the codes sorted and organized, comparisons made, and finally a theory is derived (Moustakas, 1994).

A subset of qualitative research is the science of phenomenology. Phenomenology describes what one perceives, senses, and knows through one's experience (Moustakas, 1994). In phenomenological investigations, data are collected through interviews. The interview utilizes open ended questions (Moustakas, 1994). When selecting research participants, there are no pre-requisite criteria. The only requirements are that the participant has experienced the phenomenon, is interested in understanding its meaning, is willing to participate in an interview, and permits the interviewer to record and publish the data (Moustakas, 1994). Unlike with quantitative research, sample size selection for phenomenological research remains equivocal (Onwuegbuzie, 2007). The number of recommended participants generally ranges from six to ten when conducting interviews (Creswell, 1998; Kuzel, 1992; Morse, 1994). A small sample size is beneficial because it allows the researcher to more carefully analyze and interpret the interview findings (Bode, 2012).

CHAPTER 3

AIMS OF THE INVESTIGATION

The purpose of this study is to evaluate and assess how orthodontists and GPs perceive Invisalign treatment outcomes. Specifically, we would like to determine which outcome parameters GPs and orthodontists use to judge successful treatment and what differences exist between the two groups. The expected outcome is a coordination of qualitative data that provides insight into what GPs and orthodontists perceive as successful treatment outcomes and to understand the value systems of clinicians.

CHAPTER 4

METHODS

4.1 Sample Selection

Prior to data collection, Temple University's Institutional Review Board (IRB) approved this investigation and granted exempt status (Protocol 25374). The sample of expert clinicians consisted of three orthodontists from Temple University Kornberg School of Dentistry, Department of Orthodontics and three general practitioners. All participating clinicians provide orthodontic treatment with Invisalign in their private practices. The participants were selected based upon their willingness to participate and the availability of pre-treatment and post-treatment digital study models. After receipt of an initial explanatory and consent letter, the orthodontists and GPs agreed to participate in this study. This letter is found in Appendix A. The expert clinicians are as follows:

1. Dr. Brian Gray is a general dentist who has been in private practice in for over 33 years. He is a member and instructor at the L.D. Pankey Institute, the Dawson Institute, and the Institute for Advanced Dental Studies. He is an international dental lecturer and has spoke in over 200 US cities and eight countries. Dr. Gray is the longest tenured faculty member and the number one certification speaker for Align Technology, the parent company and manufacturer of Invisalign. He has certified over 20,000 dentists in Invisalign. He is an Invisalign Premier Provider and has treated over 1,500 cases with Invisalign since its inception.

2. Dr. Ronald Klein is a general practitioner. He is a fellow of the Academy of General dentistry and is a faculty member in the Department of Restorative Dentistry at Temple University Kornberg School of Dentistry. He is a certified Invisalign provider and has been in private practice for over 38 years.
3. Dr. Elizabeth Spannhake is an orthodontist who has been in private practice for over 34 years. She is a Clinical Associate Professor in the Department of Orthodontics at Temple University Kornberg School of Dentistry. She is an Invisalign Gold provider and has treated several hundred cases with Invisalign since its inception. She has taken numerous continuing education courses on the Invisalign appliance system.
4. Dr. Natalie Parisi is an orthodontist who has been in private practice for over 23 years. She is a Clinical Associate Professor in the Department of Orthodontics at Temple University Kornberg School of Dentistry. She has been a certified Invisalign provider for over 10 years and has treated over 1,000 cases. Her practice has been given VIP Diamond status, one of the highest levels bestowed to Invisalign providers. This makes her one of the leading providers of Invisalign in the nation.
5. Dr. Ali Husain is an orthodontist with over 21 years of private practice experience. He is a Clinical Associate Professor in the Department of Orthodontics at Temple University Kornberg School of Dentistry. He has been a certified Invisalign provider for over 18 years. He has treated over 2,500 cases with Invisalign and is designated a VIP Platinum provider. This places him in the top 5% of providers in the nation.

4.2 Interviews

An interview was conducted with each orthodontist and GP to gain insight into how each clinician perceives Invisalign treatment outcomes. The questions were open-ended and were constructed to obtain qualitative data from orthodontists and GPs. The investigator privately interviewed each clinician. The interview was recorded using a digital audio recorder and subsequently transcribed at their consent.

After the interviews were conducted, the investigator transcribed the interviews verbatim. The transcripts were saved as word documents on the investigator's personal computer. After reviewing the transcribed interviews, recurring key words and phrases were identified. These key words and phrases were grouped according to themes. Each theme was assigned a color. The variables coded include the outcome parameters measured in the OGS.

4.3 Qualitative Analysis

Through analysis of coded phrases, observations and trends could be noted. Ultimately, such data were fractured, conceptualized, and integrated to form a theory. The observations were compared between question, responder, and by clinician type.

4.4 Case Selection

Each clinician was asked to identify and select four orthodontic cases that they treated using the Invisalign system. They were asked to select cases which they perceived as having had the "best" outcome. Cases inclusion criteria were:

1. adult patient age 18 years or older

2. class I malocclusion
3. treatment without extraction of permanent teeth
4. availability of pre-treatment and post-treatment digital study models

For each case selected, the clinicians provided the investigator with pre-treatment and post-treatment digital study models in STL format. All cases were de-identified prior to distribution to the investigator to maintain patient anonymity.

4.5 Discrepancy Index

A post-graduate resident from the Department of Orthodontics served as a blind examiner. The examiner was calibrated to perform the DI on pre-treatment digital study models using the OrthoCAD software. Calibration was performed with the aid of the ABO DI scoring system manual and the OrthoCAD manual. Measurements were performed by one examiner to ensure consistency. The DI parameters measured include overbite, overjet, anterior open bite, lateral open bite, anterior crossbite, posterior crossbite, crowding, and antero-posterior occlusal relationship. The cephalometric parameters were not included in the score since lateral cephalometric radiographs were not collected. The purpose of the DI scores was to determine if initial case complexity influences clinicians' perceptions of treatment outcomes.

4.6 Objective Grading System

A separate post-graduate resident from the Department of Orthodontics served as a blind examiner. The examiner was calibrated to perform the OGS on post-treatment digital study models using the OrthoCAD software. Calibration was performed with the

aid of the ABO Grading System for Dental Casts and Panoramic Radiographs manual and the OrthoCAD manual. Measurements were performed by one examiner to ensure consistency. The OGS parameters measured include tooth alignment, marginal ridge height, buccolingual inclination of posterior teeth, occlusal contacts, occlusal antero-posterior relationship, overjet, and interproximal contacts. The root angulation parameter was not included in the score since panoramic radiographs were not collected. The purpose of the OGS scores was to help identify which outcome parameters may influence clinician perceptions of treatment outcomes.

4.7 Quantitative Analysis

To ensure examiner reliability, five cases were randomly selected. DI scores and OGS scores were re-measured by their respective examiner. Re-measurement occurred five months after initial data collection. Intra-class correlation coefficients were determined to assess intra-examiner reliability. Mean DI and OGS scores were compared between each group using independent t-tests. Any significant differences were identified.

CHAPTER 5

RESULTS

5.1 Discrepancy Index

The three orthodontist clinicians provided a total of 12 pre-treatment digital study models. The DI scores for the 12 cases are displayed in Table 1.

Table 1. Orthodontist Cases Pre-treatment DI Scores

Pre-treatment Case	Total DI Score	Overjet	Overbite	Anterior Open Bite	Lateral Open Bite	Crowding	Occlusal Relationship	Lingual Posterior Crossbite	Buccal Posterior Crossbite	Other
A	10	2	2	0	0	2	0	0	2	2
B	4	0	3	0	0	0	0	0	0	1
C	15	4	0	3	0	0	4	0	0	4
D	8	0	0	0	0	0	4	0	0	4
E	7	2	0	0	0	2	2	0	0	1
F	6	2	2	0	0	2	0	0	0	0
G	4	0	0	0	0	4	0	0	0	0
H	6	2	2	0	0	2	0	0	0	0
I	3	2	0	0	0	1	0	0	0	0
J	9	0	0	0	8	1	0	0	0	0
K	4	0	2	0	0	2	0	0	0	0
L	12	1	0	0	0	7	4	0	0	0

The two GP clinicians provided a total of seven pre-treatment digital study models. The DI scores for the seven cases are displayed in Table 2.

Table 2. GP Cases Pre-treatment DI Scores

Pre-treatment Case	Total DI Score	Overjet	Overbite	Anterior Open Bite	Lateral Open Bite	Crowding	Occlusal Relationship	Lingual Posterior Crossbite	Buccal Posterior Crossbite	Other
A	2	0	0	0	0	2	0	0	0	0
B	26	0	0	8	16	0	2	0	0	0
C	6	2	0	0	0	2	2	0	0	0
D	8	0	0	0	0	0	4	0	0	4
E	11	3	0	4	0	4	0	0	0	0
F	10	2	2	0	0	4	0	2	0	0
G	8	2	0	0	4	2	0	0	0	0

A Shapiro-Wilk test of normalcy for the total DI score indicates that both the orthodontist group ($p=0.329$) and the GP group ($p=0.056$) have a normal distribution. A Levene's test for equality of variances for total DI score is insignificant ($p=0.298$) which indicates that equal variances between the two groups can be assumed. The orthodontist cases have a mean total DI score of 7.33 compared to a mean total DI score of 10.14 for the GP cases. Independent samples t-test indicates that this difference is not significant ($p=0.287$). DI was re-scored by the same examiner five months after the initial scoring to determine intra-rater reliability. DI scoring was highly reliable with an intra-class correlation coefficient of 0.996.

5.2 Objective Grading System

The three orthodontist study participants provided a total of 10 post-treatment digital study models. The OGS scores for the 10 cases are displayed in Table 3.

Table 3. Orthodontist Cases Post-treatment OGS Scores

Post-treatment Case	Total OGS Score	Alignment	Marginal Ridges	Buccolingual Inclination	Occlusal Contacts	Occlusal Relationship	Overjet	Interproximal Contact
A	66	3	6	5	32	9	11	0
B	64	6	5	9	28	6	10	0
C	67	5	4	2	30	9	17	0
D	60	0	7	5	30	5	13	0
E	61	9	3	6	29	3	11	0
F	65	14	6	5	25	4	11	0
G	54	9	4	5	19	6	11	0
H	61	5	3	4	33	3	12	1
I	72	9	7	5	27	11	12	1
J	68	5	1	1	41	6	14	0

The two GP study participants provided a total of seven post-treatment digital study models. The OGS scores for the seven cases are displayed in Table 4.

Table 4. GP Cases Post-treatment OGS Scores

Post-treatment Case	Total OGS Score	Alignment	Marginal Ridges	Buccolingual Inclination	Occlusal Contacts	Occlusal Relationship	Overjet	Interproximal Contact
A	64	10	4	4	37	0	9	0
B	73	5	4	4	38	10	12	0
C	71	5	5	0	34	16	11	0
D	49	10	1	1	22	5	10	0
E	66	17	0	4	26	2	17	0
F	57	2	4	4	27	5	15	0
G	62	5	5	2	31	7	12	0

A Shapiro-Wilk test of normalcy for the total OGS score indicates that both the orthodontist group ($p=0.935$) and the GP group ($p=0.817$) have a normal distribution. A Levene's test for equality of variances for total OGS score is insignificant ($p=0.250$) indicating that equal variances between the two groups can be assumed. The orthodontist cases have a mean total OGS score of 63.80 compared to a mean total OGS score of 63.14 for the GP cases. Independent samples t-test shows that this difference is not significant ($p=0.84$). OGS was re-scored by the same examiner five months after the initial scoring to determine intra-rater reliability. OGS scoring was highly reliable with an intra-class correlation coefficient of 0.909.

5.3 Qualitative Results

Three orthodontists and two GPs were privately interviewed. Open ended questions were asked. The questions listed in Table 5 were used as a guide. The audio-recorded interviews were transcribed and can be found in appendices B-F. The transcribed interview responses were coded according to key words and phrases. Coded words and phrases for each clinician's responses were organized into tables. Coded data

were compared between orthodontists and GPs to identify any differences, similarities, or trends in responses between the two groups

Table 5. Open-ended Interview Questions

Number	Question
1	How do you define successful orthodontic treatment? What do you perceive is most important for obtaining a successful treatment outcome? Is there any one factor that you feel contributes the most to a successful outcome?
2	What do you like best about the outcomes of the cases you selected?
3	What do you like least about the outcomes of the cases you selected? Is there anything that you would do differently? Would you have treated any of the cases differently?
4	How does the initial complexity of a case influence your opinion on the overall success of treatment?
5	What do you perceive is the greatest challenge for obtaining a successful treatment outcome with Invisalign? Are there any additional challenges to obtaining a successful treatment outcome?
6	How do you believe patients define successful orthodontic treatment? What do you perceive is most important to them?
7	Do you believe that general dentists and orthodontists perceive treatment outcomes differently? How? What do you perceive as the difference?
8	In your opinion, how do you perceive patient's feel about Invisalign treatment completed by a general dentist compared to an orthodontist? Do you believe that patients feel differently about each clinician group's ability to achieve a successful outcome? Do patients have different levels of confidence for Invisalign treatment completed by general dentists compared to orthodontists?

5.3.1 Initial Case Complexity

Each clinician was asked why they selected the Invisalign cases that they did and what factors they felt contributed to their complexity. Coded responses for each clinician are included in Table 6.

Table 6. Initial Case Complexity

Factors Related to DI:	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Overjet</i>			-flared anterior teeth -protrusion	-anterior cross-bite -front teeth were very protruded -excessive overjet -protrusion	
<i>Overbite</i>					
<i>Anterior Open Bite</i>	-anterior open bite				
<i>Lateral Open Bite</i>		- posterior open bite			
<i>Crowding</i>	-lower crowding	-lower crowding - crowding	-upper very crowded -overlapped -crowding -crowded	-crooked upper front teeth -crooked lower front teeth -crowding of the lower -a lot of lower crowding -lower incisor crowding -lowers were significantly crowded	-mild to moderate crowding -severe crowding -severe severe crowding
<i>Occlusal Relationship</i>	-half cusp Class II -not a solid Class I -half cusp -close to half cusp				-end on end Class II -mild Class II -Class II Division 2 -malocclusion was mild to moderate
<i>Lingual Posterior Crossbite</i>	-cross-bite				
<i>Buccal Posterior Crossbite</i>					
<i>Other</i>	-diastema			-diastema -small laterals	-more spacing

					-severe skeletal asymmetry -cant
Table 6. (Continued)					
Factors Not Related to DI:	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Alignment</i>	-lateral being flared out -canine is really pushed out there			-minor upper rotations	-lingually positioned incisors
<i>Archform</i>	-narrow arch -squared arch -look at expanding -rounding out the arch		-narrow -V-shaped	-narrow upper arch -narrow upper arch -narrow upper arch	
<i>Other</i>	-wear -wear on the canine -wisdom teeth -tooth size discrepancy		-different torques -retroclined -retroclined -skeletal cases -extraction cases		-torque
<i>Esthetics</i>			-dark corridors		
<i>Gingiva</i>				-large black triangle	
<i>Restorative considerations</i>				-significant number of gold crowns -porcelain crowns	

The expert clinicians' responses included several criteria related to the DI including overjet, anterior open bite, lateral open bite, crowding, occlusal relationship, and lingual posterior crossbite. Responses related to the "other" category of the DI included presence of a diastema, small lateral incisors, generalized spacing, severe skeletal asymmetry, and occlusal cant. DI criteria not mentioned included overbite and buccal posterior crossbite.

Two of three orthodontic clinicians mentioned overjet as a factor that contributes to initial case complexity. GP clinicians did not mention overjet. Both excessive overjet and negative overjet or anterior crossbite were considered complicating factors for their selected cases. Open bite contributed to case complexity for one GP clinician, but did not for the orthodontists. Crowding was unanimously mentioned by all clinicians as a factor that contributed to initial complexity for their selected Invisalign cases. One orthodontist and one GP described that an occlusal relationship that is not an ideal Class I occlusion adds complexity to Invisalign cases. One GP listed posterior crossbite as a complexity while orthodontists did not.

Several additional factors unrelated to the DI that contribute to initial case complexity were mentioned by the clinicians. These factors included tooth alignment, archform, esthetics, periodontal considerations, restorative considerations, and incisor torque. Two orthodontists and one GP mentioned misaligned and rotated teeth. Two orthodontists and one GP described narrow or V-shaped archforms as complicating factors for their selected Invisalign cases. Presence of dark buccal corridors, black triangles, and a significant number of pre-existing permanent restorations were mentioned by orthodontists. Two orthodontists considered incisor torque, specifically retroclined teeth, as a complicating factor for their Invisalign cases. GPs did not mention incisor torque. One GP listed tooth size discrepancy as an initial complexity.

5.3.2 Final Case Outcome

Clinicians were asked why they perceived the final outcomes to be successful for the Invisalign cases they selected. Coded responses for clinicians are included in Table 7.

The expert clinicians' responses included several criteria related to the OGS. They include alignment, marginal ridge height, occlusal contacts, occlusal relationship, overjet, and interproximal contacts. Buccolingual inclination of teeth was not mentioned.

Table 7. Final Case Outcome

Factors Related to OGS:	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Alignment</i>	-lined up nice -lined up -alignment -lined up -align the teeth	-anterior got aligned -teeth are aligned well		-great alignment	-fairly well aligned -alignment of the upper and lower anterior teeth -alignment -resolution of the lower crowding -alignment
<i>Marginal Ridges</i>		-arches are more level	-marginal ridges		
<i>Buccolingual Inclination</i>					
<i>Occlusal Contacts</i>	-good posterior occlusion -settled	-posterior occlusion -posterior occlusion -good occlusion	-occlusion		-bicuspid seat down
<i>Occlusal Relationship</i>	-occlusion -well socked in -occlusion socked in -bite is balanced and stable -good canine guidance -bite all balanced -balanced and stable -stable -function -great guidance -occlusion	-occlusion is functional -anterior guidance -anterior guidance	-socked in -very excellent occlusions -perfect Class I -balanced occlusion	-better bite -CR to CO shift was gone -good canine guidance -good occlusion -posterior occlusion remained the same -good functional occlusion	-nice posterior interdigitation -posterior interdigitation -good intercuspation

	-settled				
<i>Overjet</i>		-overjet -good overjet	-overjet -proper overjet -good overjet -improving the overjet	-did not have any cross-bite - elimination of the occlusal trauma or the cross bite -went from having flared laterals	-jump the anterior cross-bite -cross-bite

Table 7. (Continued)

Factors Related to OGS:	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Interproximal Contacts</i>	-closing that space -close the space		-space closed	-diastema was closed	
Factors Not Related to OGS					
<i>Overbite</i>	-nice extrusion -closing the gap	-good overbite -overbite	-closed the bite -overbite		
<i>Esthetics</i>	-anterior esthetics -nice smile -esthetic -overall smile -overall esthetics	-esthetic -esthetic	-rid of the little troughs -incisors finished very beautifully -broad smile -midlines are aligned	-Smile esthetics -great smile arc -increased incisal display -increased width in his smile -increased smile width -increased smile esthetics -midlines were on	-midline is nice and coincident -midlines are coincident
<i>Patient Satisfaction</i>	-happy -met his expectations	-patient satisfaction -patient was happy	-excited	-patient being happier	

	-meet his needs	-patient was satisfied -Patient satisfaction -patient was very happy -patient was satisfied and happy -patient was happy		-patient being happy -patient satisfaction	
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Table 7. (Continued)

Factors Not Related to OGS:	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Archform</i>	-I love the arch -good expansion -rounded well -dome shape -arch form -expansion -arch form -inter arch width -expansion -good expansion -expansion -inter arch width		-rounding of the arches -well-rounded arches -arch expansion -rounding of the arch -broadening the upper arch form -round arches -good arch dimensional change -broadening the arch form		
<i>Periodontal Considerations</i>	-not have any recession -soft tissue architecture		-periodontal health	-improved gingival architecture	
<i>Other</i>			-torque was great -anterior torque	-speed of the treatment	-upper incisor angulation -cant correction -cant nicely corrected -cant correction
<i>Patient Compliance</i>			-very cooperative -very motivated		

			-highly motivated -highly motivated -highly motivated		
<i>Restorative considerations</i>			-optimal space for an implant		
<i>Improved hygiene</i>				-flossing	

Table 7. (Continued)

Criticism of Final Outcome:	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Occlusal Contacts</i>	-bit open	-posterior occlusion -better occlusion			-incomplete settling of the second molars -second molar contacts -better contact -open bite on that side -residual buccal open bite -molar occlusion
<i>Alignment</i>	-bring those canines in -move #15 a little bit -rotate in #10			-eliminate all of the rotations -lower premolars could be rotated better -lower right central could be rotated -would have maybe just dimpled the aligner -couple of more aligners -alignment -could have probably had one refinement	-malalignment of the incisors -incomplete rotational correction

				-tucked her left lateral in -upper left lateral -done a refinement	
<i>Occlusal Relationship</i>	-more solid Class I -occlusion -more stable Class I -less of a half cusp -canine guidance -full Class I -more Class I -sock in the sagittal				-second molar intercuspation -incomplete Class II correction -posterior interdigitation -Class II was not corrected completely -occlusion posteriorly -posterior occlusion -better intercuspation

Table 7. (Continued)

Criticism of Final Outcome:	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Archform</i>	-rounding it out				
<i>Gingiva</i>	-black space		-black triangles	-gingival recession	
<i>Restorative considerations</i>	-laterals are too wide -honor golden proportion -laterals are too wide -aim for better golden proportion -laterals are too wide				
<i>Overbite</i>			-overbite -overbite		
<i>Overjet</i>				-overjet	-buccal overjet -more posterior lingual torque
<i>Other</i>			-more torque in the incisors	-large front teeth	-torque

			-anterior torque	- retroclined (lower incisors)	-more lingual torque on the upper second molars -excess buccal crown torque
<i>Esthetics</i>				- enameloplasty	
<i>IP Contacts</i>					- spaces

Good alignment of teeth was specified by two orthodontists and two GPs as an important criterion in their perception of treatment success. Obtaining level marginal ridge height and level arches was mentioned by one orthodontist and one GP. Factors related to occlusal contacts were mentioned by two orthodontists and two GPs. In their judgment of treatment success, these clinicians repeatedly described the cases to have good overall occlusion. All clinicians unanimously identified proper occlusal relationships to be an important factor in their perceptions of treatment success for their selected cases. This ideal occlusal relationship was described as "socked in", "stable", and with "good canine guidance". All orthodontists and one GP mentioned overjet. Specifically, they mentioned finishes with "good overjet" and corrected anterior crossbite. Their perception of what constitutes good overjet was not elaborated upon. Lastly, two orthodontists and one GP mentioned elimination of interproximal spaces as an important criterion.

Several factors not related to the OGS were described by the clinicians in their perception of treatment success for their selected Invisalign cases. Responses included factors related to overbite, esthetics, patient satisfaction, archform, periodontal considerations, patient compliance, restorative considerations, oral hygiene, and incisors torque. One orthodontist and two GPs mentioned finish with "good" overbite and closure

anterior open bite as important factors that contributed to their successful outcomes. All clinicians described esthetics as an important component for successful outcome. The GP responses were non-specific and simply mentioned "good esthetics." The orthodontists specifically mentioned coincident midlines, reduced buccal corridors, and increased incisor display. Two orthodontists and two GPs specified patient satisfaction as an important component of successful Invisalign outcomes. One GP and one orthodontist specified archform. Specifically, their responses described expansion of the dental arches and achievement of "well rounded" arches. Two orthodontists and one GP mentioned factors related to the periodontium as components of treatment success. These clinicians valued preservation of periodontal health and improvement of gingival architecture. One orthodontist attributed Invisalign outcome success to patient compliance. One orthodontist described the patient's ability to floss after treatment as a contributor to outcome success. Two orthodontists described incisor torque as a contributor to their cases' successful outcome. GPs did not mention incisor torque.

Clinicians were asked what they did not like about the outcomes of their selected Invisalign cases or what could have been improved. Areas of criticism included factors related to occlusal contacts, alignment, occlusal relationships, overbite, overjet, interproximal contacts, archform, periodontium, restorative considerations, esthetics, and torque. Responses from one orthodontist and two GPs indicate that they would have liked to see better posterior occlusion and bite settling. Two orthodontists and one GP indicated that alignment could have been improved. Particular emphasis was given to incomplete rotational correction. One orthodontist and two GPs criticized the final occlusal relationship of their cases. These clinicians believed that final intercuspation could be

more ideal. One GP was critical of final archform and desired a more "rounded" arch. Two orthodontists and one GP criticized the final periodontal condition. Responses indicated a lack of satisfaction with black triangles and recession. One GP was critical of final lateral incisor position in a case in which restorative build ups for maxillary lateral incisor were indicated. One orthodontist was critical of final overbite. Two orthodontists lacked satisfaction with final overjet. One orthodontist would have liked to perform enameloplasty to improve esthetics. One orthodontist was critical of residual spaces. All orthodontists were critical of final incisor torque while GPs did not mention torque.

5.3.3 Definition of Successful Treatment Outcome

Clinicians were asked how they define a successful treatment outcome with Invisalign. Coded responses for each clinician are included in Table 8. Responses included factors related to occlusal relationship, patient satisfaction, alignment, occlusal contacts, overbite, overjet, patient compliance, archform, buccolingual inclination, periodontal health, esthetics, and knowledge of the Invisalign system. All clinicians unanimously agree that occlusion is an important determinant of treatment outcome success. Responses indicate that successful outcomes include those with stable, socketed in occlusion. Both GP clinicians additionally specified canine and anterior guidance as important factors. One orthodontist and one GP mentioned patient satisfaction as a component of treatment outcome success. Two orthodontists and two GPs mentioned straight and well aligned teeth. One GP specifically indicated straight anterior teeth. Both GP clinicians specified occlusal contacts with a cusp to fossa relationship as an important criterion for treatment outcome success. Orthodontists did not mention this. One orthodontist and two GPs mentioned overbite. GPs specifically described a range of 0.5

millimeters to 3.5 millimeters as ideal. Overjet was mentioned by one orthodontist and two GPs. Patient compliance with Invisalign was mentioned by one orthodontist and one GP as an important factor. One GP indicated that expansion with "maximum inter arch width" is an important component of Invisalign outcome success. Good buccolingual inclination is an important factor for one GP.

Table 8. Definition of Successful Treatment Outcome

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Occlusal Relationship</i>	-Stability and function -class I occlusion -anterior guidance -canine guidance -no working or non-working interferences -stability -occlusally stable -no CR/CO discrepancy -occlusion -stable and balanced	-occlusion -Canine relationships -molar relationships -anterior guidance	-good occlusion -good occlusion -occlusion	-occlusion -function -good function -not any occlusal trauma to the bite -no CO to CR shift -good function	-socked in occlusion -Class I if possible -six keys
<i>Patient Satisfaction</i>		-Patient satisfaction			-patient being satisfied
<i>Alignment</i>	-line up	-straightening out the lower anterior -upper anterior	-well aligned arches -well aligned arches -straight teeth	-teeth are straight	

<i>Occlusal Contact</i>	-cusp fossa relationship -posterior distal occlusion -cusp fossa relationship	-cusp to fossa contacts -cusp to fossa relationship			
<i>Overbite</i>	-overbite -20 to 30 percent range -1 to 3.5 millimeters	-0.5 to 1 mm overbite	-overbite		

Table 8. (Continued)

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Overjet</i>	-overjet -shim stock space -slight anterior coupling	-0.5 mm overjet	-normal overjet		
<i>Patient Compliance</i>		-patient compliance	-very cooperative		
<i>Archform</i>	-expand -expansion -maximum inter arch width -arch form				
<i>Buccolingual Inclination</i>	- buccolingual inclination is good				
<i>Other</i>	-little or no IPR				
<i>Gingiva</i>	-do not hurt the tissues				
<i>Esthetics</i>			-esthetic -smile line -good facial result -esthetic smile -white teeth -fill their smile	-smile esthetics	-symmetric midline -nice smile arc -nice upper incisor display -upper midline on

					<ul style="list-style-type: none"> -nice smile arc -nice balanced esthetics -upper incisor display -tooth size and morphology -nice smile arc
<i>Knowledge</i>			<ul style="list-style-type: none"> -how the plastics works -understand attachments -biomechanics -overcorrect -sequencing 		

One GP also indicated that performing little or no IPR is important for successful treatment outcomes. Maintaining periodontal health was a response of one GP. Responses of all orthodontists included smile esthetics while GP responses did not. Smile esthetic parameters described were related to smile arc, incisor display, and coincident midlines. One orthodontist indicated that a firm knowledge in the biomechanics of Invisalign is important to achieve successful outcomes.

5.3.4 Influence of Initial Case Complexity on Treatment Success

Clinicians were asked how initial complexity influences their perception of the overall success of an Invisalign case. Coded responses for each clinician are included in Table 9. Two orthodontists and two GPs agreed that initial case complexity significantly influences their perception of outcome success. One orthodontist mentioned that a complex case does not preclude the obtainment of a good result. One orthodontist and one GP were in agreement that a very complex case that finishes with a less than ideal

outcome may still be considered successful. The outcomes of these complex cases are judged less critically. They agree that a simpler and less complex case must finish ideally to be considered successful.

Table 9. Influence of Initial Complexity on Treatment Success

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Complexity has influence</i>	-complexity plays a big role	-Absolutely		-yes -complexity definitely does change how you feel about your finished result	-certainly is a huge factor
<i>Complexity does not have influence</i>					-do not necessarily think that complexity could dictate you from having a great result
<i>More complex can be less ideal</i>		-starting with a very complicated case -may not be as ideal -improvement		-may have not finished a case perfectly -success because we made this person happy -not as hard on yourself if it was very difficult	
<i>Simpler must be more ideal</i>		-simpler case -finish pretty much ideal		-easy case and you get 90 percent improvement, then you are like it is still not great	

5.3.5 Challenges for Obtaining Successful Treatment Outcomes

Clinicians were asked what they perceive to be challenges to obtaining successful treatment outcomes with Invisalign. Responses included factors related to patient compliance, knowledge and understanding of the Invisalign system, occlusal relationship, extraction treatment, anterior open bites, periodontal considerations, restorative considerations, ankylosis, molar uprighting, asymmetries, overbite, and overjet. Coded responses for each clinician are included in Table 10.

Table 10. Challenges for Obtaining Successful Treatment Outcomes

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Patient Compliance</i>	-compliance -compliance -compliant	-patient compliance	-Patient cooperation	-patients tend to want to give up -patient compliance	-compliance
<i>Knowledge</i>		-diagnosing -knowledge -doable -diagnosis - orthodontic knowledge -doable case - constitutes an ideal result		-expertise of the doctor	-education
<i>Expansion</i>		-expanding the arch			
<i>Occlusal Relationship</i>	-Sagittal	-Class II cases		-posterior occlusion -does not seem to lock -posterior teeth are just not locking in -big bite discrepancies -occlusal plane change	-Class II correction is the most unpredictable
<i>Extraction</i>	-serial extraction -Extraction cases -Anterior extraction cases -Bicuspid extractions	-extraction cases			

Table 10. (Continued)

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Other</i>	-uprighted second molars - unexpressed movement - unpredictable movements -ankylosed tooth		-skeletal component -anchorage -skeletal component -asymmetry -extruding teeth -Torque -anterior torque - palatal root torque	-ankylosed tooth -ankylosed	-Lateral incisors
<i>Anterior Open Bite</i>	-big open bites -big open bites		-intrude the molars -open bite cases		
<i>Gingiva</i>	-thin biotype -recession				
<i>Restorative considerations</i>				-implants in place -implant tooth -when you have a bridge -highly restored patients	
<i>Overbite</i>				-extrusion of maxillary laterals -deep bites	
<i>Overjet</i>					-overjet correction

5.3.6 Patient Perceptions of Successful Treatment Outcomes

Clinicians were asked how they believe patients define successful Invisalign treatment outcomes. Responses included factors related to esthetics, occlusal contact,

improved oral hygiene, alignment, TMJ stability, overjet, and overall patient satisfaction.

Coded responses for each clinician are included in Table 11.

Table 11. Patient Perception of Successful Treatment Outcomes

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Esthetics</i>	-social six	-Esthetics -esthetics	-beautiful smile -look youthful -nice smile -Esthetics -beautiful smile -youthful smile -pretty smile	-not even smile esthetics	-smile esthetics -nice coincident midline -good smile esthetics -Smile arc
<i>Occlusal Contact</i>		-bite	-occlusion -function		
<i>Improved hygiene</i>		-able to floss lower anteriors			-want to floss
<i>Alignment</i>	-look straight			-straight teeth -teeth are straight -majority is straight teeth	-anterior alignment
<i>Other</i>			-joint stability		
<i>Overjet</i>				-some look at overjet -do not want overjet -fix my overjet	
<i>Patient Satisfaction</i>					-their experience in your office -quick -least painful -reasonable cost -their chief complaint

All clinicians agree that patient perceptions of treatment success are primarily driven by esthetics. The clinicians believe that patients simply want a nice smile with emphasis on the anterior teeth. Responses of one orthodontist and one GP included a

stable bite and occlusion. One orthodontist and one GP believe that an important factor for patients is improved ability to floss and maintain good oral hygiene. Responses of two orthodontists and one GP include tooth alignment. These clinicians believe that patients simply want straight teeth. Improved TMJ stability was mentioned by one orthodontist. One orthodontist indicated that some patients desire reduced overjet. Overall patient satisfaction with the treatment experience was mentioned by one orthodontist. Specifically, patients desire quick, comfortable, cost effective treatment with their chief complaint addressed.

5.3.7 Patient Perceptions of the GP and Orthodontist

Clinicians were asked how they perceive patients feel about Invisalign treatment that is completed by a GP compared to treatment completed by an orthodontist. Coded responses are included in Table 12. Responses indicate that GPs and orthodontists perceive that most patients do not appreciate a difference. Clinicians feel that patients have equal confidence in the ability of both orthodontists and GPs. Patients do not seem to care who is performing the treatment and simply view Invisalign as a product that anyone can use. Three orthodontists and one GP indicated that there are some patients who may perceive a difference between orthodontists and GPs. Clinicians described these patients as those that are more educated or that are undergoing re-treatment.

Table 12. Patient Perception of GP and Orthodontist

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>No difference</i>	-millenials, It is a commodity - commodity	-do not seem to care -anyone can do -same treatment -they will not care -all the same service -Not much -don't think so -do not think that they do	-do not realize there can be a difference	-I do not think that they know the difference -I do not think that they know the difference -do not think that they think this person is trained and this person is not -I do not think that they know the difference at all -the majority, no (ability) -they think it is a product -we are just a middleman -before treatment, probably no (confidence)	-I do not think that they know the difference
<i>Difference exists</i>	-huge value -decent value -good value - orthodontist will get or end up with a better result -more confidence		-educated people that understand -expectations are high when they are going to an orthodontist	-there are some -they were not happy with it	-have to be retreated -yes (ability) -yes (confidence)

	in specialists -Yeah				
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5.3.8 GP and Orthodontist Perceptions of Treatment Outcomes

Clinicians were asked whether or not they believe that GPs and orthodontists perceive treatment outcomes differently and what differences they believe exist. Coded responses are included in Table 13. All the clinicians believe that a difference does exist. One orthodontist and one GP believe that orthodontists care more about final occlusion. One GP believes that GPs generally are more attentive to final gingival margin levels compared to orthodontists. Two orthodontists believe that orthodontists care more about periodontal health. One orthodontist also feels that GPs do not believe that orthodontists are cognizant of decalcification and poor oral hygiene. The responses of one orthodontist and one GP indicate that GPs' Invisalign treatment is more attuned to the facilitation of restorative work and implant placement. Two orthodontists and one GP perceive a difference in knowledge and education between orthodontists and GPs. A GP clinician indicated that GPs are more knowledgeable of occlusion. The orthodontists believe that GPs lack knowledge of orthodontic tooth movement, anchorage, eruption patterns, and growth. Orthodontists also do not feel that GPs give enough attention to posterior teeth and correction of occlusion.

Table 13. GP and Orthodontist Perception of Treatment Outcomes

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Difference exists</i>	-yes	-Absolutely	-Yes	-Yes	-Ido -more realistic (GP)
<i>Occlusal Contact</i>		-final occlusion -occlusion	-occlusion		
<i>Gingiva</i>		-gingival levels -gingival margins are level -level gingival planes	-periodontal health		-not very cognizant of hygiene and decalcification
<i>Restorative considerations</i>		-implant treatment planning -restorative bend -creating space			-facilitate their restorative care and periodontal treatment
<i>Knowledge</i>	-smart part of their class -All you have to do is pass -better handle on occlusion (GP) -ones that do not care		-posterior teeth are somehow not given an equal amount of attention -finishing details - details in how to move posterior teeth -education -tremendous difference in what the general dentist will provide and knows -lack of knowledge -how teeth move -Anchorage -how children grow -when teeth erupt -do not count teeth	-do not think that the general dentist knows what to look at -do not think that they know how to fix the bite -do not think that they have ever been educated to do it -do not really have knowledge of tooth movement	

Table 13. (Continued)

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
<i>Alignment</i>			-anterior teeth are in good alignment	-just want the teeth straight -just straighten the teeth -just straightening teeth -just looking at straight teeth -about 12 year old molars when the orthodontist is doing the work	-work on alignment
<i>Esthetics</i>			-esthetic result -anterior results		
<i>Patient Satisfaction</i>				-what the patients want -Giving the patient what they want	
<i>Occlusal Relationship</i>				-do not care about a Class II -do not get into fixing the bite	-not going to try to make any occlusal correction

All three orthodontists are in agreement that GPs primarily focus on the alignment and straightening of teeth. One orthodontist believes that GPs are mostly concerned with anterior esthetics. The response of one orthodontist indicates that GPs prioritize patient satisfaction and simply give them what they want. Two orthodontists indicated that GPs do not attempt to correct occlusal discrepancies.

5.3.9 GP and Orthodontist Perceptions of Case Complexity

Clinicians attributed certain factors to case complexity. Coded responses are included in Table 14. GPs may find growing patients or patients with open bites as more complex and difficult to treat. The responses of one orthodontist and one GP indicates that crowding is simple to resolve with Invisalign. Orthodontists also find open bites, elimination of interproximal spaces, and alignment to be simple with Invisalign.

Table 14. GP and Orthodontist Perceptions of Case Complexity

	Dr. Gray	Dr. Klein	Dr. Spannhake	Dr. Parisi	Dr. Husain
Treatment Concerns:					
<i>Lateral open bite</i>		-open bites - posterior open bite			
<i>Growth</i>		-still growing			
Simple Cases:					
<i>Crowding</i>		-lower anterior crowding			-resolving crowding
<i>Anterior Open Bite</i>				-Open bites	
<i>Interproximal contact</i>					-closing spaces
<i>Alignment</i>					-alignment

CHAPTER 6

DISCUSSION

This study attempted to reveal how orthodontists and GPs perceive treatment outcomes of patients treated with the Invisalign system. A specific goal was to shed light on what criteria clinicians use to judge treatment success. Five expert Invisalign clinicians were selected and interviewed to explore these important questions.

The results show that there was no significant difference in DI scores between the pre-treatment digital study models submitted by orthodontists and GPs. This demonstrates that the cases evaluated by the clinicians were comparable in initial complexity. This finding corroborates the reports of Elizabeth et al. who found no difference in orthodontist and GP perception of case complexity for simple cases with DI scores below 15 (Elizabeth, 2017). Intra-rater reliability of DI scores measured with the OrthoCAD software was high in this investigation. This is consistent with the findings of Dragstrem et al. who concluded that the OrthoCAD DI module is a clinically acceptable alternative to manual scoring (Dragstrem, 2015).

A comparison of OGS scores between the two groups again showed no significant difference. This indicates that the Invisalign appliance performed equally well for both orthodontists and GPs. This finding contradicts reports by Abei et al. who found that OGS scores were significantly lower, and therefore superior, for patients treated by orthodontists compared to GPs. Only fixed appliances were used in that investigation (Abei, 2004). This suggests that in our investigation, the lack of difference in OGS scores between orthodontists and GPs may be a limitation of the Invisalign appliance system

itself. Perhaps the quality of outcomes are limited by this treatment modality. It is evident that clinician perceptions of outcome quality do not match measurable characteristics. It should be noted that the OGS parameters are objective measurements based on static post-treatment digital study models. They do not paint a complete picture of treatment outcomes. Important factors such as smile esthetics and facial changes are excluded.

This study did not include scores from manually measured plaster model counterparts for comparison. It should be stated that the reported OGS scores in this investigation appear inflated. The mean total OGS scores were 63.80 for the orthodontist group and 63.14 for the GP group. This is more than double the typical failure cutoff score of 30. The scores in the categories of overjet and occlusal contacts especially appear to be high. These findings are consistent with those of Hildebrand et al. who in a 2008 study found a statistically significant difference when comparing total OGS scores between plaster and digital casts using the OrthoCAD software. They attributed this difference to discrepancies in the alignment, occlusal contact, and overjet category (Hildebrand, 2008). Despite the inflated appearance of the OGS scores, however, the intra-rater reliability in our investigation was excellent. This finding corroborates the reports of Hildebrand et al. where intra-rater reliability was high for OGS scores with the OrthoCAD software (Hildebrand, 2005).

The responses of the expert clinicians provide valuable insight into their perceptions of treatment outcomes. Furthermore, the utility of the parameters set forth by the OGS and their role in treatment outcome perceptions was explored. Most clinicians described alignment as a factor that contributes to their perception of treatment outcome success. However, it was not cited as one of the most crucial contributors. Perhaps, it is a

given that straight teeth at the end of treatment is a requisite and therefore this criterion did not generate much enthusiasm from the clinicians.

Marginal ridge height and buccolingual inclination are two criteria that generated little to no response from the expert clinicians. This indicates that they are of minimal importance in the perception of treatment outcome success.

Occlusal contact is an important factor for treatment outcome success. Clinicians described the presence of good posterior occlusion and occlusal contacts. The clinicians did not clearly define what kind of contact they seek. It is unknown if the occlusal contact involves broad or flat opposing surfaces versus cusps hitting the opposing tooth in a point contact. In the absence of any enthusiastic opinion, they have equal weight. Even the OGS does not clearly define what an occlusal contact can be. Such findings indicate that this standard of orthodontic excellence is not well-defined. Despite this ambiguity, we are not in a position to pass judgment and create a standard of occlusal contact because data collected in this investigation are inadequate for such an initiative.

All five expert clinicians perceive that a Class I occlusion is essential for treatment outcome success. The static examination of models indicates a very high level of enthusiasm for Class I intercuspation. Some patients may have worn down tooth surfaces while others may have sharp cusps. Both conditions may still be called Class I and considered ideal. This indicates a wide spectrum of finishes. In general, people are often interested in perfect locked-in gears. While this may be acceptable for machinery, there is a paucity of information of why locked in cogs of two wheels should be more functional in the mouth. There are many moving parts in the mouth. The locked in

occlusion does not necessarily make more efficient mastication. Instead, we should find a way to define what a more useful and functional occlusion should be.

Despite Class I occlusion being an important criterion for treatment outcome success, most clinicians were not fully satisfied with the final occlusion and felt that it could have been better in most of their cases. Perhaps Invisalign is not a good appliance to correct sagittal discrepancies and adjunct appliances should be used to achieve an ideal result. Further, clinicians deemed these cases complete despite not reaching their ideal end result. The treatment was cut off at some point which was considered "good enough."

Overjet generated much enthusiasm from the clinicians. The experts in this investigation perceive a finish with minimal overjet as successful. The utility of overjet and what is considered to be ideal warrants discussion. A mild increase in overjet can create an impression of youthfulness or may provide better upper lip support. There is a lack of evidence that mild deviations from normal would have deleterious consequences.

Clinicians described closure of interproximal spaces as an important outcome for success. Open spaces may lead to repeated food impaction. Over time, this may erode periodontal support and contribute to crestal bone loss. Wide spaces, however, can be healthy in situations in which the spaces are easily cleansable and food does not stick. Nevertheless, open spaces are usually considered cosmetically undesirable.

Several criteria not included in the OGS were described by the clinicians in discussing their perception of treatment outcome success. Overbite is an important factor. Specifically, clinicians seek to close open bites or reduce overbite in deep bite cases. Clinicians consider an ideal overbite to be a minimal overlap of the anterior teeth. The standard to which overbite is considered to be ideal remains somewhat undefined. One

expert clinician considered ideal overbite to be 20 to 30 percent incisor overlap or a range from 1 to 3.5 millimeters. Another clinician described ideal overbite as 0.5 to 1 millimeters. Most clinicians agree that establishment of anterior guidance is important. If this is the case, then perhaps a finish with deeper than normal overbite should be desired to achieve posterior disarticulation more easily.

The achievement of an esthetic final result is a unanimous desire. The orthodontists were more specific in their definition of smile esthetics. Coincident midlines, consonant smile arc, and reduction of buccal corridors were mentioned by the orthodontists, but not by the GPs. While a consonant smile is often considered desirable, other esthetic factors must also be considered (Sarver, 2001). For example, a consonant smile may not be able to compensate for poor morphology of anterior teeth. Canines can often make patients unhappy due to their morphology. Smile esthetics are often subjective. Some may prefer incisal edges to be perfectly level while other may prefer lateral incisor edges to be slightly intruded relative to the central incisors. Some may prefer lateral incisors that are labiolingually more prominent while others may prefer them to be set back. The clinicians did not provide any clue as to how lateral incisors might be best used to define attractive esthetics.

Patient satisfaction is important to the clinicians in their perceptions of treatment outcome success. For whatever outcome is achieved, whether the clinician is an orthodontist or GP, the patient is excited and satisfied with the improvement they get. Despite various outcomes, patients are unanimously happy with their result. Perhaps this is because no one told them what they should look like. Patients may be less critical of

treatment outcomes and are satisfied with any improvement (McKeta, 2012). Similar to a haircut, they will be equally happy no matter where they got it done.

Archform garnered interest from some clinicians. For success, the wider the arch, the more preferred, but not unanimously. One orthodontist and one GP are very interested in arch expansion with Invisalign. In the child patient, more expansion can be achieved because the transverse dimension is still increasing (Bjork, 1997). In the adult patient, however, the life sciences is not in a position to make new bone (Bjork, 1997). Despite biological limitations, arch expansion is still heavily desired by some.

The effects of Invisalign treatment on the periodontium is an important area of consideration for the clinicians. They are cognizant of periodontal health as they aim to avoid recession and finish with good gingival architecture. This is consistent with evidence that Invisalign is superior to fixed appliances for periodontal health (Lu, 2018).

Patient compliance generated a high level of enthusiasm from all clinicians in their perception of outcome success with Invisalign. Clinicians felt that this is perhaps the most important determinant of success. One GP described poor compliance as "the downfall of clear aligner therapy." Excellent compliance, however, can significantly benefit the clinician. One orthodontist described how "the harder cases become easier cases when you have good patient cooperation." This opinion cannot be limited to Invisalign. It is also crucial with fixed appliances as success may be influenced by patient compliance with elastic wear and oral hygiene. This principle is also not unique to orthodontics. It applies just as well to people who purchase a gym membership. They will only become stronger or healthier if they are compliant and go to the gym regularly.

Some clinicians find certain cases to be more challenging than others when the Invisalign system is used. For example, the GPs perceive extraction cases as a significant challenge with Invisalign. The orthodontist clinicians do not. Orthodontists often cited skeletal asymmetries and discrepancies as significant challenges. The quality of the orthodontic challenges may be much greater and more sophisticated for orthodontists compared to those of the GP.

Based on the evidence gathered in this investigation, initial case complexity influences clinicians' perceptions of treatment outcome. Both orthodontists and GPs agree that initially complex cases are a greater challenge to achieve an ideal finish while less complex cases are simpler. This is in agreement with Cassinelli et al. who concluded that severity of malocclusion influences orthodontists' perception of a case difficulty (Cassinelli, 2005). These seemingly complex adult cases will be treated to what can reasonably be accomplished. They are not expected to have the same ideal textbook finish as an adolescent. If the clinician perceives the adult case as complex, they will still perceive a less than ideal outcome as successful.

When asked about patient perception of treatment outcome success, the clinicians were in overwhelming agreement. The clinicians believe that patients prioritize an esthetic smile and well aligned anterior teeth. Occlusal and functional concerns are either secondary or of little to no concern for patients. Based on these responses and the desire to satisfy patients' expectations, perhaps arguments for treating only the social six and leaving the rest might have some validity.

The expert clinicians were asked whether or not they believe that patients perceive a difference in Invisalign treatment performed by an orthodontist versus a GP.

Orthodontists and GPs were in agreement. They believe that the majority of patients do not perceive a difference in treatment that is carried out by an orthodontist versus a GP. Clinicians feel that patients view Invisalign as a commodity and that the clinicians are distributors of pieces of horseshoe shaped plastic. The patient is not buying treatment, but buying plastic. Despite this seemingly frustrated sentiment, both orthodontists and GPs also agreed that there does exist a niche of patients that do appreciate the difference between the specialist and GP. These patients are regarded by the clinicians as those that are more educated or those who have been previously treated by a GP and seek re-treatment from an orthodontist.

The expert clinicians were finally asked whether or not they believe that GPs and orthodontists perceive treatment outcomes differently and what differences they believe exist. Most orthodontists and GPs acknowledge that a difference in education and knowledge of the Invisalign system exists between orthodontists and GPs. One orthodontist described how "the general dentist, most of them, have good intentions, but there is a lack of knowledge which the patients do not know about." It is the belief of the same orthodontist that GPs "are catering to the one goal that the patient wants and not viewing them holistically." Whereas many patients may not appreciate the specialty education and expertise of the orthodontist, GPs do and acknowledge their own limitations. Orthodontists perceive that GPs only care about alignment of teeth and do not care about occlusion. GPs do not say so. Perhaps, their goals and perceptions of treatment outcome success are more sophisticated than they get credit for.

No study is without limitations. One seemingly obvious limitation of this investigation is the small sample size. A total of three orthodontist and two GP clinicians

participated. One additional GP had been recruited, but dropped out. Participation of these five clinicians yielded a total of 19 pre-treatment cases and 17 post-treatment cases available for analysis. Post-treatment digital study models were not available for two of the cases in the orthodontist group. This small sample size of cases may have influenced our quantitative results.

While a small sample size may be a limitation for quantitative analysis, it is actually desired for qualitative investigations such as ours. The small sample size allows the investigation to be more focused. Each interview can be more carefully interpreted and analyzed to identify possible trends. Too large a sample size provides excessive data which becomes exceedingly difficult to navigate. The use of open-ended questions in this investigation was advantageous due to the investigation's exploratory nature. It should be noted that with qualitative studies such as this one, findings cannot be generalized to an entire population. While our goal was to select expert Invisalign clinicians to represent their respective profession, these findings cannot be assumed to be true for all orthodontists and GPs. Instead, they may be utilized to form a theory as to how orthodontists and GPs perceive Invisalign outcome success and may help guide future research on this topic.

The results of this exploratory investigation open many avenues for future areas of study. Quantitative studies can be performed with larger sample sizes to compare how well Invisalign performs in the hands of the orthodontist compared to the GP. This is an area of interest given seemingly different perceptions of outcome success between the two groups. The current investigation points towards a separation between the two groups in the perception of smile esthetics. Future studies may further elaborate on differences in

perception of smile esthetics between orthodontists and GPs. This would be of great value since smile esthetics are believed by our clinicians to be of paramount importance to patients. As mentioned earlier, the expert clinicians were never perfectly satisfied with the end result of their Invisalign or fixed appliance cases. They were always able to point out certain things that could have been improved upon. Despite not fully reaching their ideal goals, they cut off treatment at some point and considered treatment to be complete. What is this cutoff point and what allows them to make the determination that treatment is satisfactorily complete? These questions warrant further investigation.

As an *envoi*, we should note that studies of this nature can never reveal the perfection of treatment results with such alternate appliances. An unequivocal definition of perfection does not exist in orthodontics. As stated by one orthodontist in this study, "I think that all orthodontists aim for, if it is not perfection, it is excellence in the treatment." Clinicians will strive for the best result possible, aware that "perfection" may be unattainable.

The decision to cut off Invisalign treatment at some point is not always that of the clinician. As another orthodontist described, "one of the issues that you might find with Invisalign is that the patients tend to want to give up a little bit sooner than we do because they have the ability to do that." Patients are sometimes reluctant to go for another refinement to further detail their case. They are already satisfied with the result that has been obtained. This is not necessarily the case with fixed appliances where detailing seems to blend in with their overall treatment.

Attempts to evaluate orthodontic outcomes and to define treatment success are frequently driven by objective parameters. These may include measurements of overbite,

overjet, Class I occlusion, or any others that comprise the OGS. To do so, however, does not paint a complete picture. As one orthodontist described, patients are "buying into an experience." The success of a case strongly relates to the patient's experience at the clinician's practice and is not necessarily equal to measurable treatment outcome parameters. This is part of what makes orthodontics so unique.

CHAPTER 7

CONCLUSIONS

The purpose of this investigation was to explore the perceptions of Invisalign treatment outcome amongst orthodontists and GPs. The study employed qualitative research methods to identify which outcome parameters the clinicians use to judge treatment success and to identify any differences between the two groups. Our purpose was not to pass judgment on or compare the quality of Invisalign case finishes between orthodontists and GPs. Rather, the significance of this investigation is that it sheds light on potential differences in treatment goals between the two groups. This ultimately affects how patients are treated with this popular appliance system. Based on the data collected, the following conclusions can be made:

1. Orthodontists perceive incisor torque and smile esthetics as important criteria for successful aligner treatment. In contrast, GPs do not.
2. Orthodontists and GPs unanimously perceive Class I occlusion as an important criterion for successful treatment.
3. Orthodontists and GPs agree that patient compliance is one of the greatest challenges to obtain successful outcomes with Invisalign.
4. Orthodontists and GPs believe that patients seek esthetics and cannot perceive a difference between orthodontist and GP treatment.

Differences exist between orthodontist and GP perceptions of what constitutes successful Invisalign treatment outcomes. Currently employed standards of excellence can be found in a wide spectrum of finishes; however, they are incapable of defining the excellence of

finish. Selective standards differentiate the GPs from orthodontists, but agreement exists for ambition to finish in Class I occlusion. Esthetics and torque are valued higher by the orthodontists than are by the GPs. The utility of current standards-of-care need to be questioned and redefined.

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APPENDIX A
CONSENT FOR RESEARCH

Title of research:

Orthodontist and General Practitioner Perceptions of Invisalign® Treatment Outcomes

Investigator and Department:

Temple University Kornberg School of Dentistry, Department of Orthodontics

Orhan C. Tuncay, DMD (PI)

Nicholas Terrana, DMD (Resident)

Why am I being invited to take part in this research?

We invite you to take part in a research study because you are an orthodontist or general dentist instructor at Maurice H. Kornberg School of Dentistry. Additionally, you were identified as an Invisalign provider.

What should I know about this research?

- Someone will explain this research to you.
- Whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide.

Who can I talk to about this research?

If you have questions, concerns, or complaints, or think the research has hurt you, contact the research team at 3223 N. Broad Street, Philadelphia, PA 19140. You may call at (973) 641-6952 or e-mail at nterrana812@gmail.com.

This research has been reviewed and approved by an Institutional Review Board. You may talk to them at (215) 707-3390 or e-mail them at: irb@temple.edu for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

Why is this research being done?

It has been reported that a level of agreement between orthodontists and general practitioners exists in evaluations of orthodontic treatment need. Perceptions of treatment outcome between the two groups, however, remains equivocal. It is also shown that orthodontists judge malocclusions more critically than do general practitioners. Currently, there are a number of grading systems proposed to objectively assess treatment outcome. The American Board of Orthodontics (ABO) has adopted the Objective Grading System (OGS) as a way to fairly assess final result in orthodontic treatment. Previous studies have used the OGS to compare outcomes between cases treated with Invisalign® to traditional fixed braces. Despite such numerous reports, there is a paucity of studies that objectively compare Invisalign® outcomes in the hands of orthodontists and general practitioners. To shed light on this uncertainty will help discern the perceptions of efficacy of Invisalign® treatment among different dental professionals. Simply put, when do clinicians call a treatment satisfactorily “done” and are there disparities in this judgment between the general practitioner and orthodontist clinicians?

What happens if I agree to be in this research?

Participation in this study, as well as any results or information obtained as a result of this study, will not affect any professional relationship or standing. The names of participants will be kept confidential and the results of the research will only presented in an anonymous manner.

Recruited subjects will participate in a single, structured, open-ended, one-on-one interview with the investigator. The interview will be conducted at the Podray Orthodontic Clinic at Temple University Maurice H. Kornberg School of Dentistry. The interview will be conducted to gain insight into what each clinician perceives as successful treatment with Invisalign. The interview will be recorded using a digital audio recorder and subsequently transcribed.

Each participating subject will be asked to identify four orthodontic cases that they treated with Invisalign in their private practice. Inclusion criteria for these cases include adult patients age 18 years or older, Class I malocclusion, and treatment without extraction of permanent teeth. Pre-treatment and post-treatment digital study models will be electronically provided to the investigator in the form of an STL file. The digital study models will be electronically viewed in the Podray Orthodontic Clinic using the OrthoCAD software program. Pre-treatment digital study models will be scored according to the ABO Discrepancy Index (DI). Post-treatment digital study models will be scored using the ABO OGS.

What happens to the information collected for this research?

To the extent allowed by law, we limit the viewing of your personal information to people who have to review it. We cannot promise complete secrecy. The IRB, Temple University, Temple University Health System, Inc. and its affiliates, and other representatives of these organizations may inspect and copy your information.

APPENDIX B

DR. BRIAN GRAY TRANSCRIBED INTERVIEW

How do you define successful orthodontic treatment?

Stability and function would be, if I had to break it down, I would say that is the most important thing. Proper function for me is going to be not necessarily Class I, but ideally class 1 occlusion and it is going to be a cusp fossa relationship. It is going to be anterior guidance with posterior distal occlusion. It is going to be canine guidance with no working or non-working interferences. There should be a standard amount of overjet and overbite. It is going to be different for everyone. For me, generally, I like something in the 20 to 30 percent range in an ideal arch for overbite. So one to 3.5 millimeters. I like shim stock space for my overjet. So slight anterior coupling is the way I interpret that, but if I ever feel fremitus then I know that I have too much which is something that I do not want. I'd guess that's it. That's good.

Is there any one factor that you feel contributes the most, if you had to pick a just one thing?

If I had to pick one thing for a successful case it would clearly be stability because if it is not stable then the case will unravel I am a huge proponent that it has to be occlusally stable. I am very big on having no CR/CO discrepancy. Centric relation and centric occlusion. I think people now a day's prefer to use for CR they say "seated condylar position" and for CO, "maximum intercuspal position". Basically I want those guys to be as close as possible or to match and I finish my cases to that. Anything less than that is not going to be success.

Okay we can go on to looking at the cases now. We can look at the first case that you selected. Can you tell me about this first case and why you selected it?

She came in in 2013. You can see that she is pretty socked into Class I on the right and almost a half cusp Class II on the left. Her chief concern, if I am not mistaken, is due to that lateral being flared out and due to lower crowding. Her canine is really pushed out there. She has a narrow arch. Here it is squared, but the bicuspid are dipped in. One of the things that I really look at now, doing a lot more with Invisalign cases especially someone like hers, I would expand the heck out of this more than I used to. I am really a big proponent of expansion and little or no IPR if I can get away with it. IPR might be necessary but this is a clear example where I would now look at this and I am looking for maximum inter arch width here and getting these guys pushed out making a better arch form and making sure that the buccolingual inclination is good.

Looking at the final outcome, what do you like about the outcome of this case?

This case lined up nice. I like the way this finished. One of the things that I am looking for a lot with Invisalign cases is to make sure that we have good posterior occlusion. You will hear a lot of this about posterior open bites. There is a lot of fallacy associated with it being from the thickness of the aligner. It is maybe five percent of the time. It is almost always a collapsed envelope of function. It is jamming these front guys back. The top they hit the bottoms and it pushes the jaw back and it opens it up. When I see something like that I want to make sure that this is settled and the way that we will do that is that we will use a T scan to make sure that the bite is verified. So I love the arch on this now. It is brought way out from where we were. It has good expansion. It is rounded

well. I like the dome shape with it. I like the occlusion. I think that we have everything well socked in. If I were to discuss with her the idea of moving things sagittally a little bit more to get things seated, and that it would take some extra time, she was like "you know can you make the teeth match right?" I can make them match pretty much the way they were and fit a little bit better. So we did equilibration when we were done and we were completely happy with how this case turned out. If I were to esthetically improve it I would bring those canines in a bit more, but otherwise I am happy with it.

If you had to pick one thing that you like the best about this case, what would it be in terms of the finish or outcome?

I like the arch form on the top. For both arches compared to where we started. We got nice expansion. Her concerns were completely esthetic. A lot of people might look at this case by just treating the anterior which would be a tragedy because the anterior crowding is related to that narrow arch. So I like the way that it turned out. I think that it is a very nice arch form I really like the inter arch width there. It turned out very well. If I could do something to improve it, I could move #15 a little bit more. I am certain that I got the occlusion socked in.

Is there anything else that you think could be more ideal about this finish, or anything else that you would change? Is there anything that is deviated from what you might consider a perfect outcome?

The occlusion on the left. To get that into a more solid Class I. I want the mesiobuccal cusp of that upper first molar to fit into the groove a little bit better, but

these guys all fit in well together and match. That is about it. I think that would be the only thing. I know that the bite is balanced and stable and I am sure that it is still that way. I am happy with how it turned out.

Do you have any other general comments about this case?

One of the things that I also keep a close eye on is where my canines are extended. I want to make sure that we have good canine guidance. Sometimes these guys can be a little bit deep and I want to intrude them a little more just so that I can make sure that it is balanced and not excessive where it may lock her in and it was not in her case.

Okay great. We can move on to case two. Can you tell me about this case and why you selected it?

This is another nice esthetic case. Her teeth were kind of wacky. With her once again you will see that she is not a solid Class I. She is kind of half cusp on both sides. Arch is again, I would probably expand this more than whatever the final Clin Check would show. I would look at expanding a little bit more. One of the things that we talked about was the wear. If you can get the teeth into a better position you can possibly slow that down. In particular I showed her just the canine the wear on the canine. So I would definitely look at expanding this case more and rounding out the arch. It is definitely flatter on the right side. It does not have as nice of a round curve to it. The arch matches what we see on the lower as well. Ortho is leaving the occlusion the way that it was. In her case it was not bad at all. I did more of an esthetic set up and made sure that we had the bite all balanced when we were done. So I guess that the next question would be what

would I do differently, or what would I improve? So that would be to get her into a more stable Class I and less of a half cusp. She is probably 50 years old or mid 50's. She has already flattened out these cusps into a full group function on both sides so getting her balanced and stable would be the best thing. One of the things that we talked about was adding some canine guidance. She said can you just round out the arches and I said sure.

So if you had to pick the number one best thing that you like about the outcome, what would that be?

I think that we have nice anterior esthetics for her which was her big concern. To make sure that we have a nice smile. You can see that we have some fairly nice expansion here. I would have probably looked at rounding it out a little bit more. Otherwise I think that it is nice. If I had to pick on something here, once again the second molar, I know I have occlusion here, but it does not look as nice. It looks a little bit open here, but it is much better than where it started.

So the number one thing that you liked the least would you say is the second molar open bite?

Yeah I would look at bringing that down. The number one thing, if I had unlimited time for her, would be to put her into a full Class 1, but I am not even sure if I would want to do that because she is stable and I do not know if there would be a whole lot gained spending an extra year trying to get some sagittal movement to correct that probably with elastics. Just that, but I would probably leave that bite. I like it.

Any other general comments about this case?

Maybe I would rotate in #10 a little bit more. I would probably bring that mesial in another millimeter. I would probably tuck that back. I would definitely bring that in. That is probably it.

Okay so we can go on to case three. Can you tell me about this case and why you selected it?

So this is quite an interesting case. He has a few things going on. He was a nice Class I to begin with if I am not mistaken. He is Class I on the left and close to half cusp on the right. He had wisdom teeth that I think he ended up getting extracted afterwards. His concern was that he had this anterior open bite and he had a cross-bite. We were able to get nice extrusion with him in this case. This is something that really changed his look, his smile. That is why I was really happy with it. I got good expansion with him. He said that his snoring decreased which I thought was interesting. With this case, I was very happy. The crowding for him was a little less of a concern and I was comfortable with being able to line things up and not have any recession. In fact I think I could have probably improved things a little bit. Look at #25 where it started and it does not get any worse. We got things lined up and put into position. If I had to pick what I like about it, I think I got a great esthetic result.

Esthetic in terms of alignment, or what in particular?

When I talk about esthetic for him, I talked about his overall smile. Just the alignment and closing the gap. The crowding was not as much of a concern as the gap

was. I was really happy with how it turned out and the way that everything fit together. If I was to be picky about something I may not be as happy with that little kind of black space there between the canines on the right side. But the function was good and I am happy with the way that those guys guided off of one another and I had things lined up the best that I could. To fix that at that point would be some sort of cosmetic or minor prosthetic option which did not bother him. He was thrilled.

So for the canine, would you have preferred to have that more in a Class I position, or had more sagittal correction?

I would have loved to have a little bit more Class I on that. I think it would have helped out, but he had already had good canine guidance so I was happy. For every case I always do at least one refinement. Sometimes two, three, or maybe more. I get the occlusion socked in before I do and equilibration. In his case we were kind of able to get those guys so that they would have great guidance when they were done and I was very happy with that. Also we got a great amount of expansion with him. I was like, "Wow we were really able to make room." He was very happy.

So can you summarize what was the number one thing that you liked best about the outcome?

The overall esthetics and the amount of inter arch width. I think we did a nice job being able to give him more space to make the tongue fit better and being able to align the teeth. I do not think that there was any IPR with this case.

What was the number one thing that you would have changed or would have liked to see improved?

I would have probably liked to sock in the sagittal and a little bit more. Once again I am being picky. I am happy with this. I like the way that those guys fit.

Any other general comments about this case?

No, he treated very easily.

We can go on to the fourth case. Can you tell me about this case and why you selected it?

His chief concern is the diastema there. We had a conversation about that. This was a tooth size discrepancy. He had some bonding on those teeth and he wanted to close the space. I explained that the teeth are too small and you cannot close that without it banging on the bottom teeth. You cannot make the lid smaller than the jar, otherwise it will not fit. So he understood and I explained what we will do is we will line everything up as best we can. I think that we did a restorative option. Once again we expanded and I probably did some IPR on the bottom here to help get things lined up. I was happy with the occlusion. It looks like that we kept the same bonding.

What would you say that you like the best about this case?

I met his expectations of closing that space. I used a combination of restorative and orthodontics. That is probably one of the things that has been great for general dentists for Invisalign is to be able to do the combination of restorative and orthodontic

cases that are simple. It has also been a really great thing for our profession. I work with a ton more orthodontist now that pay more attention to this and would not try to do this purely orthodontically. I think that it goes both ways. I think that there is still a huge amount of education that has to occur. I routinely say that I do not think it is an Invisalign thing. I think that it is in ortho thing. You can script a bite a million ways and it does not have to be Invisalign. It can be any of the clear aligners. They all do the same thing. The teeth do not know how they move, they just move. Probably the worst that I see up there is the six month smiles that cause a ton of crushed envelopes of function. The thing that I loved is that we were able to meet his needs. It was not a long case. It was pretty quick. We were able to get him settled. The big thing is to be able to manage the bite and get it exactly where I want it to be. I did not really have to do any sagittal correction, but I did have to get things lined up. I got things to as ideal as possible for him.

In terms of the finish, the thing that you like best was being able to close those spaces?

Yes, as best as possible. We were able to bind things up and close the space a little bit and finish with a bonding.

Is there anything that you do not like about the outcome, or anything that you would have changed?

I think that the laterals are too wide. I would have potentially squeezed those central incisors together more and left more space distal to the central. Maybe on either

side of the lateral and made the central a teeny bit wider so I could honor golden proportion a little better. The laterals are too wide here when I look at them. So that is probably one way that I would address it. Bring those centrals together and do any restorative. I would aim for better golden proportion there.

Is there anything else, orthodontically, that you would have done differently?

Occlusion was easy on this. I didn't have to do anything. This is more of an anterior case.

Any other general comments about this case?

Those laterals are too wide. So the other thing that I love doing now is whenever I have any peg laterals, what I like doing is to lingualize those as much as I can so that I can do no preparation or minimal preparation veneer. So before, when I used to set up, we used to just try to get them in position. Now we are also looking at the soft tissue architecture. The last piece of the puzzle is now to also lingualize the laterals as much as I can so that I do not have to do any facial reduction and I can slide the veneer right over it. So I do that a lot more nowadays than I did before.

How does the initial complexity of a case influence your opinion on its overall success of treatment? Does it have any influence?

Yeah, the complexity plays a big role for me as a GP in particular. I still work close with the orthodontist and if it is a complex case, I would probably prefer to send it up the street. I do not want to get into trouble. At this point, I have done everything. I

have done serial extraction cases. I have uprighted second molars, but for God's sake it is like pounding nails in your forehead. It takes a very long time. The things that I love about clear aligners is that it is a super gentle, constant force as opposed to what we generally see with most fixed. Not all cases, but most. Just more start-stop and abrupt movement compared to a constant gentle force which I really love. The role that complexity plays is that if it is a really complex case, we are getting better. Meaning that there are a lot more things that clear aligners can do that can match fixed that they could not do years ago. It cannot do everything, but likewise there are some things that clear aligners can do better than fixed. If it looks like that it has a fixed component, I stopped doing fixed about 12 years ago and mostly because I teach aligners and I cannot cheat and throw segmental on to finish a case. So everything that I have done is 100 percent aligners.

What would you consider as perhaps being too complex that you would shy away from?

Sagittal stuff is just harder. I think that the time on sagittal is really getting close. Now with elastics, especially with the pre-made hooks, save time so you can put hooks and buttons on and get close to fixed. But I also like to send it down the street because it is just a pain. Extraction cases is another. Anterior extraction cases I do not mind doing but I do not like doing very often because I think that it can kind of create other issues. Bicuspid extractions in particular. I think big open bites. We had thought maybe two years ago that the standard of care would be to treat open bite cases with Invisalign and I do not think that is the case. I do a lot of those cases. I know that I can get two to four

millimeters easily. But big open bites are difficult. I have a patient coming in that started with a 12 mm open bite. She asked if I can do it with Invisalign. I said you are an orthognathic case, a surgical case. She said "I know but can we still do it?" I said I will go as long as I can if you want. I was not able to do a superimposition to see how much correction we were actually getting. We are getting movement, but I am two and a half years into the case at this point and orthognathic surgery would have been the way. Or maybe putting elastics on there, but it is slow and tedious to do extrusion with just plastic. Same with intrusion. We felt that intrusion was going to be, when we first started with aligners, I was definitely having better results with intrusion then with fixed in my hands. I got a better result because I can control it better. I think that some of the results were maybe not as good as we thought they were. Then they came out with G5 and that had ramps and multiplanar movement and reciprocal anchorage. I look at those things and say that we made progress, but aligners are still best for tipping. They are great for tipping teeth and dealing with some minor rotations. Another example, uprighting second molars with plastic. There is some really great stuff going on. One of the huge advantages is you can get good separation without putting turbos on. With something like that you stand a much better chance taking away the inter arch forces and that is tough with a big spring. In my eyes, something that really sets Invisalign apart, one of the key things with them is that they have this massive database from the protocols where they are able to figure out what is working and what is not and determine the tooth movement assessment. If I see the blue or black dots on the Clin Check, it is going to tell me a few things. One, it is going to be challenging. Plus two, I will look into my own bag of tricks and see if it is challenging because they have not sorted out what is working best yet and the answer to

that is that I have a good answer in my office for it, or they have not sorted it out and there is not a good answer yet. So those things play a role. The other thing that I've loved about the tooth movement assessment is that it tells me that I can slow down. If I see blue or black then I know that it is not a weekly change. We know that the aligners have ten days of full expression, two days of lag, and then two days of nothing is what they aim for. You can change that by the amount of movement that you put in each aligner. So when I look at that and I see a blue or black movement, then I am probably going to go at least ten days instead of weekly because I want to express the maximum amount of movement at a minimum of eighteen hours per day before I jump into the next one. Otherwise, you end up putting the cart in front of the horse and then six aligners out, they are not tracking.

Do you like to over-prescribe when you are doing your Clin Checks?

Generally not. I do not over-prescribe, but I do build in overcorrection just as a c-chain. I use a c-chain five percent of the time. I rarely use them. I think that my techs know from my assigned preferences how I like to have my setup finish. Especially the anterior which I think is one of the biggest challenges. I have never used a c-chain to close spaces. It is not to close space. It is to reduce the anterior contact. I will never do more than three c-chains in that case. I will probably intrude as well as retract.

For example, with a deep bite case, would you ever prescribe in your Clin Check to finish with 0 mm overbite, or even anterior open bite, hoping to get some of that correction?

Yes, I do. I will tell them open up this case three millimeters. The tech will ask me if I am sure and I say do not worry. It will not fully express anyway. So that and rotations. If I have a tough rotation, I will ask for extra rotation. Usually for laterals. For canines, it is usually not worth overcorrecting, but laterals I will usually ask. However, I find that the trouble with laterals is that there are usually inter arch forces. With central incisors, I will usually ask for overcorrection on those too.

What do you perceive is the greatest challenge for obtaining a successful treatment outcome with Invisalign?

Oh, that is so easy, compliance. I tell patients all of the time, braces are on your teeth 24 hours a day. If that aligner is not in your mouth 22 hours out of the day then it is not working. We kind of know that the real number is somewhere between 18 to 22 hours, but if you tell them 18 hours then they will wear it 12 hours. So yeah, compliance is the number one thing. I tell everyone that it is the downfall of clear aligner therapy.

Are there any additional challenges from a clinical standpoint?

Yeah, another thing is unexpressed movement. For me, if I see something is not moving it is going to be one of four things. Force, space, science, or compliance. We talked about compliance already. The others are not enough force, not enough space, or not enough science. With not enough science, that is where you have unpredictable

movements. Generally, they will say that they are blue or black. That just means that they have not yet figured out how to use the plastic yeah. Not enough force is, for example, when you have an ankylosed tooth. They just do not move. With fixed I can be in treatment for four months and realize that that tooth is ankylosed. But with Invisalign your whole case is dead because all of the other movements are predicated on that tooth moving. Space is pretty easy. That is just making sure that there is enough space. It is less of an issue then it used to be. There is IPR and there is a lot more round-tripping with aligners now which I love. That has a bad connotation with fixed, but with Invisalign I am not worried about that. I do pay attention to some spots if it is a very thin biotype where if I tip it forward I can get some recession. I have done it before where I have tipped a tooth forward and brought it back and it is looking good again, but I have had others where I have brought it back and it did not improve and I have lost a couple of millimeters. I had one patient that was so happy with her bite being fix that she did not notice recession on #8 and #9. I had to stop and do a refinement to move the teeth back into a proper position to correct it. However, that is something that has stayed with me for many years. I got two of the four millimeters of recession back. When I look at my Clin Check, I want to make sure that teeth are round-tripping and that they are not going to crash. If I have those four things, I know that the case will track well and that the teeth are going to move.

Are there any outcome parameters that you find are challenging, for example in terms of obtaining ideal overbite, or overjet, or sagittal correction?

I want the easier cases. I am more selective now about the cases that I will take on. If I have someone that is very compliant and I know that in advance, then I am comfortable doing a more challenging case. If I get someone that may or may not be compliant then I do not want to do that and I just do not want to start it. I got some cases that are incredibly challenging, but the patient is just stellar with wearing the aligners and I am still able to sock it in and I love that.

How do you believe patients define successful orthodontic treatment?

I would say that 90 percent of people are looking at the social six and if they look straight then all is good in the world. Most of them will not pay attention to a completely screwed up bite. That is just completely brought home by the national tragedy going on right now that is Smile Direct. It is the perfect storm of malocclusion. We are going to have more TMJ issues with this generation than you can imagine.

Do you believe that orthodontists and general dentists perceive treatment outcomes differently?

I don't know. To some degree, yes. I think that there is an automatic filter with orthodontists. They have to be the smart part of their class to get into an orthodontic residency so they already have a nice advantage. All you have to do is pass to be a general dentist. There are ones out there that have done that and ones that do not care. Ones that are doing Invisalign because the guy down the street is and they are losing

patients to them. I have heard of guys just handing over all the boxes to patients and telling them to go away. I have seen too many cases that are just train wrecks. So I do. I also think there are a subset of dentists that actually have a better handle on occlusion than a lot of orthodontist because we deal with it every day. Generally, they are trained and there are a lot of different philosophies of occlusion. I am Pankey Dawson trained and I love it when someone says they are a gnathologist. I love it because I can have a conversation with them and I can talk and we can talk. You have an idea of what you think proper occlusion is and I do too. It is the ones that do not have any clue. Part of the nice thing about Invisalign is in the past, to a much greater degree we would send patients to an orthodontist and they would come back and their case was not finished or they did not wear their retainer and the teeth would move or maybe it was both. But with us we see that patient every six months or maybe even more frequently and it's maybe for the rest of their lives. With an orthodontist, their case is done, but with us they are going to haunt us.

In your opinion, how do you believe patients feel about Invisalign treatment that is completed by the general dentist compared to the orthodontist?

I think that in particular, there is a huge value still that patients see in seeing an orthodontist. Since I was one of the first on the east coast to do Invisalign, I was in a unique position. I was doing Invisalign before every orthodontist in the area here. There was one guy doing Invisalign downtown and that was it. He was doing Invisalign before GP's were allowed to do it and I would ask him questions. As the orthodontist started to do it, patients would ask me "Hey I heard that you do Invisalign. My kids are going to the

orthodontist. Would you want to see me or should I see the orthodontist?" I would say if you are comfortable with the orthodontist you should see the orthodontist. You will get a great result with them and you should go there. I think that patients perceive a decent value. I charged the same fees, but I can tell them that I have a lot of experience. I do Invisalign because I have to set up my cases beautifully for restorative since we are a cosmetic restorative practice. I still think that patients perceive a good value in it. I think that the millennials, the younger people, think that it should be like Amazon. Something that you can just buy on the internet. It is a commodity is what they perceive.

Do you believe that patients feel differently about orthodontist compared to general dentists and their ability to achieve a successful outcome with Invisalign?

Yeah, I do I think that generally patients perceive that an orthodontist will get or end up with a better result because they are an orthodontist or a specialist. My personal retort is that it is all based on your experience and what you consider to be a good result and that is why. Again, the ones that I work with, they know what a finished case is for me and they do not say that a case is finished until I give the green light.

Do patients have different levels of confidence for Invisalign treatment that is completed by the general dentist compared to the orthodontist?

Yes, it kind of fits into the same category. I encourage them to get three opinions or four opinions. Everyone has a different way to end up with a beautiful esthetic outcome. That is ideally for me going to be functional. I think that they would probably have more confidence in specialists especially if money was not an object.

Do you think that most patients are aware of the differences between a general dentist and orthodontist?

Yeah, I think that there is an education gap in that regard. I fault the orthodontic association for this. I fault them for coming out with these commercials saying that if you want your teeth fixed then go to an orthodontist. But why not explain why? Without the why, it is less credible. Instead, explain how orthodontists take the time to get a masters and undergo extra training. Patients do not get that. They see it as a commodity, especially the younger patients.

Do you have any general comments about anything that we talked about that you would like to mention, or do you have any closing remarks?

I am huge on occlusion. I know that the better that I can get that to match, the better off that it is. I do not believe that settling really applies to any type of tooth movement. One big thing is trying to educate people that teeth again do not know how they move. They just move. They do not care if it is Damon, Edgewise, bioprogressive, Speed, Invisalign, Clear Correct. It does not matter. There is really no magic bullet. It's how you get things to line up at the end and obviously do not hurt the tissues doing it. Creating so much force that you end up with root resorption. And you have to equilibrate and that can mean adding or subtracting, but my philosophy is very simple. If the teeth do not match in a bad bite and you move the teeth then how can they possibly match? They can't. They absolutely cannot. So I have to do some sort of adjusting. I may have to move the tooth more or do some restorative to get the proper cusp fossa relationship. There may

be cases where I could have gotten a better Class I relationship, but as long as everything is stable and balanced, then I am happy.

APPENDIX C

DR. RONALD KLEIN TRANSCRIBED INTERVIEW

How do you define successful orthodontic treatment?

Technically, it should be good occlusion, cusp to fossa. Canine relationships and molar relationships. As far as I treat, I am just happy if the patient is happy. Usually they have specific goals in mind like straightening out the lower anterior or the upper anterior and if they are pleased with that, then I am pleased. I also do not like to see cases that end up with open bites or posterior open bite. I like to see at least some realistic posterior contacts.

What do you perceive is the single most important factor for obtaining a successful outcome?

Patient satisfaction.

How about from a dental point of view?

Then it would have to be cusp to fossa relationship. I think even more important than that would be anterior guidance with a 0.5 to 1 mm overbite and 0.5 mm overjet so that they have a little movement in the mandibular. That would be my criteria.

Is there any one factor that you feel contributes the most to a successful outcome, other than what you have mentioned?

A factor that contributes would be patient compliance. That is absolutely essential. Other than that, no.

What would you say that you like the best about the outcomes of the cases that you selected overall?

A good esthetic outcome and again patient satisfaction. That is really what I am aiming for.

For the first case, what would you say that you like the best about this case's outcome?

The smile is esthetic and the occlusion is functional. The patient was happy with the outcome.

Is there anything that you do not like about this outcome or anything that you would have changed?

No, not in this case.

For the second case, what would you say that you like the best about this outcome?

So this was a more interesting case. This was a complex case. She came in with a posterior open bite. I reluctantly took on this case. I think the outcome looks good. It is better and the patient was satisfied and we ended with a posterior occlusion.

Looking at the final outcome, what would you say that you like the best about how it turned out?

Patient satisfaction is one thing. The anteriors got aligned. We got anterior guidance and better posterior occlusion. I had to do a little bit of occlusal adjustment for

the posterior occlusion. I would tell my patients that it is not unusual for us have to do a little occlusal adjustment at the end of treatment.

Is there any one thing in particular that you do not like about the finish, or anything that you would have changed, or would have liked to see better in this case?

I would have liked to see an even better posterior occlusion. I would have liked to use the attachments better to pull the posterior teeth into a better occlusion.

For the third case, what would you say that you like the best about this outcome?

So this case had lower crowding. You can see that it finished with a good occlusion and the teeth are aligned well.

Is there anything that you do not like about this case or that you would have done differently or would have liked to see different?

No, I was very happy with the outcome and the patient was very happy. We had a good overbite and overjet relationship and anterior guidance so that case worked out well.

For the fourth case, what would you say that you like the best about this outcome?

You can see that there was a lot of crowding in this case. The patient was satisfied and happy at the end. You can see that the arches are more level at the end.

So for this final case, overall, what would you say that you like the best about how this case turned out?

I was very pleased with the final result and the patient was happy. We got a good overjet and overbite.

Is there anything that you do not like or any one thing in particular that you like the least about this case? Is there anything that you do not think is ideal or that you would have changed, or would have liked to see improved?

No, I'm not that picky. I am not an orthodontist. I do not like to treat teenagers because they are still growing. The standard of care would be to take a ceph and I do not have a ceph. I think that is beyond a general practitioner's training. An orthodontist knows how to read cephs.

How does the initial complexity of a case influence your opinion on its overall success of treatment? Does it have any influence?

Absolutely. If I am starting with a very complicated case I think that I will be happier with a end result that may not be as ideal, but I will still be happy. I will be pleased if we make a significant improvement if it started very complicated. If it is a simpler case like lower anterior crowding then it has to finish pretty much ideal.

What do you perceive is the greatest challenge for obtaining a successful treatment outcome with Invisalign?

The greatest challenge would be, aside from patient compliance, from the dentist point of view, the greatest challenge would be diagnosing. There were instances where I did not feel comfortable with the knowledge that I had as far as determining if the treatment would be doable. So as a general practitioner the greatest challenge would be the diagnosis. There were cases where I was worried about expanding the arch and as to whether the bony housing would be expanded further.

Are there any additional challenges that you perceive for having a successful result? Perhaps from a dental point of view?

Again having the orthodontic knowledge to understand what constitutes a doable case. What constitutes an ideal result and knowing that you can finish up with a good occlusion. Again, I would not do any Class II cases or extraction cases.

How do you believe patients define successful orthodontic treatment?

Esthetics. A couple of them have been the bite. "Doctor I cannot chew on a sandwich." That has been a complaint, but mostly it is about esthetics. Believe it or not, some of them have been motivated by being able to floss lower anteriors which surprises me that some people are motivated by things other than esthetics.

Do you believe that general dentists and orthodontists perceive treatment outcomes differently?

Absolutely. I would hope so. I would hope that an orthodontist would be more particular.

What do you think that the difference is?

The final occlusion. I think that the occlusion is the entire thing. Although I have seen results from orthodontist where the occlusion is left to be desired. Especially in cases where people are occlusally aware. For example, what I mean by that is that I have cases where you put a crown on a second molar and all of a sudden, they say my bite feels totally off. You even take it out of occlusion and they still complain about it. I have remade them in occlusion and they do not like it and then I take it out of occlusion and they do not like it again. So they become, for some reason, occlusally aware. That's about one to two percent of patients and it drives you nuts.

Anything besides occlusion that you think general dentists and orthodontists feel differently about or perceived differently?

I do not know how much or not orthodontists look at the gingival levels. Whether or not the gingival margins are level. The only reason why that has become more important these days is because of implants. Speaking from my own experience that has made me more aware of level gingival planes and how important that could be if the patient has a high smile line.

Okay so you mean in terms of having the architecture being symmetric?

Yes, like with the central incisors being a little bit higher than the laterals and so on.

Anything else besides those that you can think of?

What I was talking about before I guess has a lot to do with pre-implant treatment planning in order to position things the best to get good results. I also think that the general dentist has a more restorative bend as far as where the teeth need to be. Like for instance, also creating space to allow an implant. I have seen orthodontists, and you know you want seven millimeters at least, and you'll have 6.5 millimeters and they will say, "okay, it's okay you can go ahead now." We asked for them to give us a little bit more. So that's where one difference is. Of course we are all concerned about our own needs. So the restorative dentist of course wants the space. I imagine that the orthodontist is more concerned about how long it takes to do the treatment or how difficult it is to move the posterior molars back, let's say in order to create space.

In your opinion, how do you perceive patients feel about Invisalign treatment that is completed by a general dentist compared to it being completed by an orthodontist?

They do not seem to care. They see it as being a process that anyone can do and that it is the same treatment. It's just like how do people know who a good dentist is. They don't. If he doesn't hurt them and he is nice then they like him even though he can do poor work. This is not all people. A percentage of people will just go to a clinic and they will not care what dentist they see. They will see a different dentist every time and it

does not matter to them and they think that it is all the same service to them. Which of course is an issue that I am not pleased about.

Do you believe that patients feel differently about each clinician group's ability to achieve a successful outcome?

Not much. I don't think so. The cases that I would do are the patients of ours. I do not want to treat patients that come in from another dentist. If a patient is going outside of their general dentist office then I feel that they should be treated by an orthodontist.

Do patients have different levels of confidence for Invisalign treatment completed by a general dentist compared to an orthodontist?

I can't speak for the patients, but I would hope that they would. However, I do not think that they do. There was one guy who was asking me a lot of questions so I said, look I am not an orthodontist so I do not have as many tools as an orthodontist has. I can achieve a result with Invisalign to the best that Invisalign can do. Not really, but I wouldn't say that. Invisalign can do just about anything, is my impression, if you know how to use attachments and cut outs. If you want 100 percent then go see an orthodontist. I can get you maybe 98 percent of the way there, but I will not have the tools to finish it. For a while he still came to me maybe because I spent so much time talking to him about it.

Do you have any additional comments before we finish here? Is there anything else that you would like to say or mention?

No, I think I said everything about it and about my feelings about Invisalign and how they are good with educational opportunities. It is all a matter about the individual dentist and how far they are willing to take it. I told the Invisalign reps, look I am not looking to grow my practice. I am not working to get patients from the outside. I am not looking to be an orthodontist. I am a bit perturbed by the fact that it is becoming a mail ordered thing you know it Smile Direct. But that is the way that dentistry is going. It is going towards corporate just like with the big market discount stores.

APPENDIX D

DR. ELIZABETH SPANNHAKE TRANSCRIBED INTERVIEW

How do you define successful orthodontic treatment?

Treatment is successful if you have a good occlusion. It does not have to be Class I. You have to have well-aligned arches. You have an esthetic, good result. A nice smile line. A good facial result as well. Within the realm of normal you have a normal overjet and overbite, good occlusion, well aligned arches, and mostly, because I mostly treat adults, a nice esthetic smile.

What do you perceive is the most important for obtaining a successful treatment outcome?

I think that you really have to understand how the plastics works. You really have to understand attachments. The biomechanics of moving the teeth with plastic and attachments and maybe elastics. You have to understand that, I always say what would we do if we were in braces, now there is a difference and how the teeth are moved. So I think that you have to understand the sequencing of how they move the teeth. How you have to overcorrect. I think that boils down to the Clin Check. I spend a lot of time on the Clin Check. It is not unusual for me to go back six or seven times with the technician. Each time that I look at it I see something different that I think can be improved. So I think that the Clin Check, really working your occlusion and thinking about all of the aspects of how the teeth are going to move, will contribute to you getting the best result that you can from Invisalign aligners.

What do you like the best about the outcomes of the cases that you selected?

I think that in all of these, all of them involved rounding of the arches. Getting rid of the little troughs, the dark troughs on the sides of the mouth. They all have very nice, well-rounded arches. The occlusion is tight and socked in well. Some of these are cases that I was preparing for implant so I was very pleased with how the technicians obeyed my orders. To say that I need this 7.5 millimeters. So I think with these cases I had good communication with the Invisalign technician and I had very cooperative patients. That was key to these people that I have in front of me. They were very cooperative and very motivated and I think that is a very significant part of success in Invisalign treatment. I noticed that looking at the cases that I chose that I feel finished very well, the cases involved arch expansion. Some of the cases had spacing and some had a lot of crowding, but the results of the rounding of the arch which also contributed to the esthetic of the smile. I think that they do arch expansion well because it is programmed and that definitely can give us the arch length that we need to unravel the crowding.

What would you say that you like the least about the outcomes of the cases that you selected?

I think that for some of them the overbite could have been improved. I went back here to some cases that I treated before they really talked about bite ramps so I think that may have contributed to that. I think that all of them ended up with very excellent occlusions. I would say that the overbite in three of them could have been a little bit better.

Is there anything that you would have done differently? Would you have treated any of the cases differently?

In a couple of cases I may have wanted to build in a little bit more torque in the incisors. I am looking at the those that involved space closure. Many times with space closure you get a retroclination vector. So maybe having built in a little bit more over-correction in anterior torque.

For the first case, what would you say that you like the best about the outcome of this case?

So the first case that I am going to talk about is an African American male, 24 years of age. Very inspired to have straight teeth. He wanted to move up in the world, to go to school and go to college. He was so highly motivated. He was Class I with flared anterior teeth. Also upper very crowded teeth, incisors with different torques and overlapped. The result I think it was very good. It finished with a really perfect Class I occlusion and I got all of my marginal ridges. The torque was great. The incisors finished very beautifully. I closed the bite. Again, a very highly motivated patient who used his Chewies and really did everything. I felt that this was one of the very good results.

For the second case, what would you say that you like the best about the outcome of this case?

The second case is a Caucasian adult, 54 years of age who came in with a lot of crowding. These pictures that I have here, the dentist had already taken out an incisor for periodontal reasons, but had never guided her to an orthodontist to do anything and told

her she was actually ready to have an implant and a crown. She came in a little hesitant to go forward with that. I said that we can close the space and align the teeth and you will have a great occlusion. Maintain the Class I and maybe wind up with just a little bit of extra overjet because of only having three lower incisors. I think her results turned out very well. The overjet was maybe three millimeters. The periodontal health of her lower incisors greatly improved. We did a lot of lingual root torque and I guess the bone just solidified and got better. Again, like with the first patient, this ended up with a very nice broad smile. I thought that she finished very well. Again, highly motivated and actually finished with one series and her additional aligners, maybe eight aligners. Her space closed unbelievably and quickly.

For the third case, what would you say that you like the best about the outcome of this case?

Then I have this adult woman, 59 years old who all her life said I want beautiful teeth. She kind of had a bird beak look. She had dark corridors. Her upper arch was exceedingly narrow. You could almost say it was V-shaped. While she did not have any lower anterior crowding, she did have some protrusion and it was a matter of really coordinating the arches, broadening the upper arch form, bringing back the anterior dentition to the proper overjet relationship. When you look at the before and after, she looks like a different person. Nice round arches, good overjet, midlines are aligned. She did unfortunately end up with the black triangles because of the angulation difference on her lower incisors. Really balanced occlusion. I was pleased because she had multiple posterior crowns that were fabricated under different occlusion that I was able to kind of

fit everything in. I did one modification on one crown, but this turned out to be a very good result. It shows that you can get a very good arch dimensional change with Invisalign.

For the fourth case, what would you say that you like the best about the outcome of this case?

My last case is a Hispanic woman, 29 years of age, who said, "I have a snaggle tooth." Upper central incisors were retroclined. Sort of like a Class II Division 2, although she was a Class I, but the anterior look she just did not like that. The upper incisors were retroclined and crowded. So again, this was a matter of broadening the arch form, improving the overjet and overbite, getting the anterior torque on the upper incisors that was needed to get a good balanced case. Also, preparing a site for an implant. There was a tooth that we started with that ended up with an issue so we ended up doing a mid-course correction and we provided an optimal space for an implant. She finished very well and the general dentist was pleased and the surgeon was pleased and her end result was that she got a spot-on perfect implant and occlusion. Again, if you look at the esthetics of her smile, and you can see it in her face, you can see it in the face of each one of these patients before and after. They were excited and their smiles got bigger. I think that people are very happy when they can look at themselves in the mirror with white, straight teeth, and teeth that fill their smile and I think that is what I got.

How does the initial complexity of a case influence your opinion on the overall success of treatment? Does that have any bearing on if you would say that you had a successful outcome? Does the initial complexity affect that?

Well these are not skeletal cases. For my skeletal patients who come in and maybe do not want to do surgery and they do not want extractions, I will get them the best aligned that I can. Over the years I have been treating more and more complicated cases, extraction cases. I do have surgical cases that I have used Invisalign to get them to the point of surgery. I think that the more complex the case is, the more thought that I'd give to it. Some of them I know are going to be maybe 20 percent fixed and 80 percent Invisalign, or 90 percent Invisalign and 10 percent fixed. Which in complicated cases there are some movements that I cannot sometimes get and it is usually related to mesiodistal root tip and sometimes the torque.

What do you perceive is the greatest challenge for obtaining a successful outcome with Invisalign?

Patient cooperation. Because I have adults and they are paying for it for the most part. I think in all of the years that I have been doing it, for 16 years with Invisalign, I can only see two patients that did not cooperate. When you have these motivated patients that keep their aligners clean, go to their regular dental appointments, wear their elastics if they need to. I am a real believer in the Chewy or whatever you use to seat it. I think that even with braces, it gives you a better result when you have motivated patients that really want to do what is necessary to get a good final result. The harder cases become easier cases when you have good patient cooperation.

Outside of patient cooperation, from a biomechanics standpoint perhaps, would you say there is any one single greatest challenge for obtaining a successful outcome?

The skeletal component, whether it is Class II or Class III. You know that you can do a camouflage. Certainly in a Class III case take out the first bicuspid and bring the lower incisors back, but you really have not brought about a facial change. Those cases are difficult and challenging. I do think that if somebody has severe protrusion and you are extracting the upper bicuspid, I still think that there is a little bit of difficulty in maintaining your anchorage. I have used TAD's, a wire placed to the TAD's to secure the molar while I am manipulating the rest of the teeth. I think that anything that has a skeletal component or asymmetry. I find that is also difficult. It takes a lot of thought and I think that those cases also end up having multiple sets of aligners, more than your standard two. It can be three or four decreasing number of aligner trays, but they end up needing more treatment.

Can you identify any additional challenges, biomechanically that you may encounter? Are there any other ones outside of skeletal discrepancies?

Well those cases where you need to intrude the molars. The technique now is sequential intrusion with supporting attachments. I still find that in those cases it is difficult so I have been backing up the posterior intrusion by placing a buccal and palatal TAD and have the patient wear an elastic just to kind of reinforce the intrusion that is occurring. I do not think that you get as much as they show you in the Clin Check and I think that is an issue with open bite cases. Also, extruding teeth. I don't think that they do it and I do not think that it stays stable because the root is not quite where you want it to

be. Torque is an issue. You want to have palatal root torque and you ask them for so many degrees. I do not think that we get that. So for the anterior torque relationship I think if you really have a problem you may not really get the result that you want.

How do you believe that patients define successful orthodontic treatment?

I think that the majority of them want to see a beautiful smile. The women, and most of my patients are middle-aged or a little more than middle-age, and they want to look youthful. They want a nice smile that fills their whole smile line. I think that is what most patients are looking for. If you did have a patient that came in with maybe secondary TMJ, they are also maybe looking for some joint stability. They may say I have far few episodes or less pain now so that can be defined as success for the patient. The majority of one's just want to look better. They have lived a long time with crooked teeth or spaced teeth and almost any improvement they would be happy with. But I think that the improvement that I provide, they are exceedingly happy because they send their friends.

Are there any occlusal parameters that you think they value highly?

These patients are very attuned to their occlusion. And one of the things that I asked during their course of treatment is how does your bite feel? Does it feel like you have equal occlusion right and left. And one of the other aspects, now this goes back to the other question about the difficulty, is that when they expand the arch, many times in the process they dropped the palatal cusp and so you have your crowns somewhat tipped out. And you will end a whole series even though I will say to them, please provide me

with palatal crown torque, that never gets quite there. There are cases where number one, I have to put them into elastics just to settle the bite similar to settling a posterior bite with braces, or I have to maybe cut the aligners and let them go away and maybe have some natural settling. Or a technique that I learned was that you take the attachments off and you give them the first of the overcorrection aligners and let them wear them part time and that part time allows the teeth to align, but you still have control of the arch form.

What do you perceive is the single most important factor to them, if you had to pick just one?

Esthetics. Esthetics then function, but they want to look better. They want a beautiful smile, a youthful smile. Most of the patients I do tooth whitening. We start it while they are in their aligners and completed afterwards. They want a youthful, pretty smile that is well-balanced. They want to be able to see their teeth and they want their friends to see their teeth.

Do you believe that general dentists and orthodontists perceive treatment outcomes differently?

Yes, I have seen too many cases treated by general dentists where the anterior teeth are in good alignment meaning that they follow a nice curve, but somehow the posterior teeth are somehow not given an equal amount of attention. I have found cases where a tooth was left in cross-bite, a tooth was rotated, a tooth was tipped. So the finishing details, or the details in how to move posterior teeth, I do not think that too

many general dentists are looking for. They are looking to give their patients what they want. An esthetic result without really considering occlusion or periodontal health. They are catering to the one goal that the patient wants and not viewing them holistically, that there is a lot more than just moving a couple of teeth around.

What do you think may contribute to this difference in perception between the orthodontist and general dentist?

One is education. Education from the standpoint of having two to three years of specialty training versus the weekend warrior classes or even those that have spent more time still have a knowledge that seems to be missing. Also, they are treating their own patients and I think that they have other motivations in that they want to do a veneer or they want to do something that then allows them to do another restorative procedure. So I think that it is all packaged into the overall treatment plan where the patient is happy with the anterior results and the dentist can kind of fix the posterior with crowns or implants.

In your opinion, how do you believe that patients feel about Invisalign treatment that is completed by a general dentist compared to an orthodontist?

I think that for the most part they do not realize there can be a difference. We have talked about the fact that the mom brings me the second child who is in Invisalign and during the course of treatment says, "she is really looking great. You know her older sister had Invisalign by our dentist." And invariably I am asked, "could you look at my child?" And I think that it boils down to orthodontic knowledge. I think that all orthodontist aim for, if it is not perfection it is excellence in the treatment. I think that

patients do not realize that there can be a tremendous difference in what the general dentist will provide and knows. I think that the general dentist, most of them, have good intentions but there is a lack of knowledge which the patients do not know about.

Do you think that there is any one particular area that the general dentist may be ignoring compared to the orthodontist?

Absolutely. Understanding how teeth move and in relation to the bones. In general, I do not think that they understand how if you have a high angle case and you wind up extruding a molar you will end up opening the bite even further. There are these little mechanical things that they do not understand. Anchorage, if you have a alveolar maxillary protrusion and you extracted the first bicuspid. I have found that a lot of the cases that I see later are still Class II because they did not maintain the anchorage. I think that is a consideration that the general dentists do not to give attention to. The last is with some of them encroaching on the teenage or growing child and they do not have an appreciation of how children grow, when they grow. I think that they also do not understand when teeth erupt, although they should. And they do not count teeth at times.

Do you feel that patients feel differently about each clinician group's ability to achieve a successful outcome?

I think that there are a number of educated people that understand that a specialist is a specialist. The old adage that if you have a heart problem you do not want to go to a general family physician. You go to a cardiologist. I think that there is a group of people who truly understand that. I am not saying that these people are all professionals. I think

that they are people who simply understand that somebody goes into a specialty program or becomes a specialist for reasons to excel above the generalist. So I just wish that it was a greater portion of our audience or our patient pool that would understand that.

Do you think that patients have different levels of confidence for Invisalign treatment that is completed by the general dentist compared to the orthodontist?

Well I think that gets back to the educated person. Their expectations are high when they are going to an orthodontist and they are expecting really good results. Sometimes results that are beyond the scope. They understand that there are many more things that can be done. I think that a large group of people believe the family dentist who they love is going to straighten their teeth and how can he not do anything but the best. Again, if their front teeth are looking great then most of them are going to be pretty happy.

Are there any additional comments that you would like to make related to what we have discussed here today?

Yes, my comment is that, and this is with regard to Invisalign in general, that they have over-promoted the ease with which Invisalign moves teeth to the general dentist. It is an illusion. Even though that they put on courses it is still an illusion that you can magically move the teeth. I wish and I know that the AAO, because I was on the communication council for years, is trying to educate the populace about specialty training and why to go to a specialist and I would like to see more of that. But when you have the money that Invisalign has for their prime time marketing it makes it very

difficult. So my comment is that they have oversold it to the general dentists. It is the detriment, to some degree, to the specialist. I have lost a lot of adult potential patients to some of my best referrers who decided to do Invisalign.

APPENDIX E

DR. NATALIE PARISI TRANSCRIBED INTERVIEW

How do you define successful orthodontic treatment?

I think that if you can, a successful orthodontic case is one where you can improve the patient's smile esthetics. You improve their occlusion so that you are giving them a good function and hopefully in the end, the teeth are straight.

What do you perceive is the most important for obtaining a successful treatment outcome?

I think that the most important thing is, if I had to just pick one, I would say good function. In the end, the patient can chew well. There is not any occlusal trauma to the bite. There is no CO to CR shift that can be causing some trauma to teeth. I probably have to say that good function is the best thing, the number one thing.

In general for the cases that you selected, what would you say that you like the best about the outcome of those cases?

Smile esthetics and the patient being happier after treatment than before. And sometimes that includes a better bite. Sometimes patients notice a shift, but sometimes, like one of the cases that I selected, was an adult who did not really like his smile. The reason that he came is that his dentist said that he had a cross-bite that is breaking down his teeth. So he knew at the end of treatment that he was in a healthier spot to protect his teeth throughout his life, but also he really liked the way his smile looked a lot better.

For the first case, what would you say that you like the best about the outcome of this case?

For the first one, he had an anterior cross-bite of the upper left two and three. He had a little bit of a diastema, crooked upper front teeth, crooked lower front teeth, Class I bite. Always did not like his smile and always tried to hide it. I think he did not know what he did not like about it, but he always tried to hide it a little bit. In the end he obviously did not have any cross-bite. The CR to CO shift was gone, the diastema was closed, good canine guidance, and good occlusion, really great smile arc, increased incisal display on his smiling, and also increased width in his smile that he liked better.

If you had to pick one thing for the first case in terms of the outcome that you are the most pleased with, or that you like the best, what would it be?

Probably the elimination of the occlusal trauma or the cross bite.

Is there anything that you did not like about the outcome for that case, or anything that you would have changed?

For smile esthetics, I would have liked to have done some enameloplasty on his upper incisors, but he did not really want to. He said maybe I will do that later or I will have my dentist do it. Other than that I was pretty happy with that case. I think that one of the issues that you might find with Invisalign is that the patients tend to want to give up a little bit sooner than we do because they have the ability to do that. I feel like the refinement is like, "okay, I am going to do extra. Oh, I do not want to do that extra. I am good with that." Whereas when you have braces on and you are going to put the final

wire in and some detail bends in, they are like, "you know it is still part of my treatment." I think that it is just a psychological thing for the patients.

For the second case, why did you select this case?

The next one is an adult woman, late 50's who was the mom of patients and for a long time I had been telling her that she should fix her own teeth. She had a very narrow upper arch and really undesirable esthetics to the shape of her maxillary incisors that caused a large black triangle. That is because of the narrow upper arch that her front teeth were very protruded, but I would not say that she had any major bite issues. Overbite was okay. She had excessive overjet due to the narrow upper arch and the protrusion of the front teeth. She had some crowding of the lower. She also had small laterals as did the last guy. She had a lot of lower crowding and I think for her, the number one benefit from my standpoint was the increased smile width and increased smile esthetics when we did some reshaping of teeth. She is a woman who claimed that people asked if she had any plastic surgery done because her face had changed enough that they thought that something is very different, which was kind of interesting. She said that three people at different parties asked if she had some work done. She told them that other than Invisalign, no. One of the other fairly big benefits to her, that I do not think she realized, is that her lower teeth were so crowded that she really had trouble flossing and now flossing was pretty easy for her. She had a dumped in, really rotated lower left three and four relationship that she really had a lot of trouble flossing. I think that is something that she was surprised would be better. I would say as far as things that I thought I could have done better with this case is I think she still has large front teeth. Even though that we did

a significant amount of reshaping of them, she still ended up with a little bit overjet. I think that her lower incisors ended up being surprisingly a little bit retroclined. So I would say that probably if I had more time to treat that one I would have probably proclined those a little bit more to help to totally eliminate all of the rotations. I think that is about it.

Do you have any other comments on the case at all?

No, I think that is it. I think that the lower premolars could be rotated better, maybe even the incisors a little bit.

For the third case, why did you select this case?

So this patient is a little bit interesting because one of the advantages I think that Invisalign offers us over braces is that if you want you can choose not to move posterior teeth. So she had a really nice Class I occlusion with some gold crowns, a significant number of gold crowns, and she had porcelain crowns on the premolars. So that would be a tough case to correct with braces. Her Chief complaint I think was lower incisor crowding. So minor upper rotations, but lower incisor crowding. I think that Invisalign is very great for that because you can say to them, "do not move the posterior teeth. I am going to do IPR on the lower anterior, but do not change the posterior occlusion." They can do exactly that which you cannot do with braces. I think for me that was the most significant thing for this case. That we can do it without moving teeth and get great alignment. The uppers were not that crowded, but the lowers were significantly crowded

and that great alignment in the end without having to mess up the posterior occlusion or risk messing it up.

If there was any one particular thing that you like best about the outcome of that case, what would you say it would be?

I would say that the posterior occlusion remained the same. That we were able to do it without disturbing it. And I would say if there were any negatives to that case that, you know if I look at it, maybe the lower right central could be rotated a tiny bit more.

Would you have treated it any differently if you could have?

No, maybe just if she would have cared about that lower incisor I would have maybe just dimpled the aligner or gotten her a couple of more aligners to do that. But it was so minor that she thought that it was perfect and she did not want to do that. She loved it. She thought it was great.

For the fourth case, why did you select this case?

The last one I chose because part of what is a successful orthodontic case is the patient being happy and this patient treated out in five months and she was thrilled. So maybe alignment was not as good as it could have been. She could have probably had one refinement which she did not have. But she was thrilled that she went from having flared laterals, which she hated her whole life, to straight teeth in just five months. So really I chose that case because I think that some of the success is patient satisfaction and she was thrilled. I would have tucked her left lateral in a little bit further, but we said to

her you know with Invisalign you can always come back within that 5 years. I told her that she can come back if she wants and she, "said I probably won't, but I will keep that in mind." So the last one I chose for that reason and that she ended up with a good functional occlusion, midlines were on, she did not mind that her left lateral was just a tiny bit forward, and in her mind it was 99 percent better than it had been and she was thrilled. She had gingival recession on her lower left central which got better in that time. I like the fact that with Invisalign you can really control where you want to put the root of the tooth. So for that one, a little bit different reason for liking the outcome, that had to do with speed of the treatment.

In terms of something objective for the outcome, in terms of perhaps alignment, overjet, for example objective parameters, what would you say you like the best for that case?

I would say probably her improved gingival architecture upper and lower got a lot better.

Is there anything in particular that you like the least about it?

What I like the least about that case is that her upper left lateral is still a tiny bit flared.

Is there anything that you would have done differently, or would you have treated it any differently?

I would have probably done a refinement just to say let's really detail this. She was just really not interested.

Any other comments on that case, or any of the four cases that you selected?

I do not think so.

How does the initial complexity of a case influence your opinion on its overall success of treatment?

Sometimes you look at the before and after and you look at the after and you may have not finished a case perfectly, but you look at the beginning and you are like, wow that was really bad, so okay that was a success because we made this person happy. Maybe we did not get ideal overbite and overjet in this case, but the patient is thrilled and never had to wear braces. So you did not cause any harm, you improve the bite, maybe you did not get it to be perfect. Maybe you took it from 100 percent overbite to maybe 25 percent overbite. I think that yes, the complexity makes it, not that you do not want to finish the case perfectly, but you are not as hard on yourself if it was very difficult and you got 90 percent improvement and you did not get that last little bit. Whereas if you had an easy case and you get 90 percent improvement, then you are like it is still not great. You started out with it being pretty good in the first place. I think that the complexity definitely does change how you feel about your finished result. It may not be

a board case, but from where it started to where you got it, and the patient understood that there are going to be some compromises, it is still successful.

Is there any one thing in particular that would make you consider a case to be more complex? Anything that you look at it and you think that this is a very complicated case? Any one parameter?

I think what complicates cases the most is when they already have implants in place. You get locked into a tooth that you cannot move and that tooth may not be where it really should be. When I trained in orthodontics, we always had to pick one tooth that we were going to base the case around. In other words, let's say that you like your lower incisors. You pick that and say, "how can I get everything to fit around these lower incisors and their position?" Or with the smile, let's say that you really like the upper canine and its height and you think, okay I am going to keep that and base the case on that. If you have an implant in place, then all of a sudden you either have to abandon that tooth totally in my treatment or I have to build the case around that tooth and it may not be the one that I want to build it around. Or even an ankylosed tooth is what really throws you because sometimes you do not know that is ankylosed and you are trying to move other teeth and things are not happening the way that you think it should and everything happens backwards to the way that you think it should happen. So I would say either an ankylosed or implant tooth really throws you off.

What do you perceive is the greatest challenge for obtaining a successful treatment outcome with Invisalign?

I think that sometimes the posterior occlusion gets really messed up. I do not know why because it used to be that people were creating posterior open bites and it was because there was anterior interference. I think that orthodontists that use a lot of Invisalign know to be fairly aggressive with IPR to make sure to make up for a tooth size discrepancy and things like that, but still sometimes you know when you have braces you can really get someone to wear box elastics and lock everything in because you have that flexibility. You have the slop in the bracket so wearing elastics allows you to get that to all settle. When you have Invisalign, even if you say to the patient, okay I am going to put buttons on and you are going to wear box elastics, it just does not seem to lock in even though that the Clin Check said it was. So sometimes you get cases that you are like, these posterior teeth are just not locking in well and you do not like your posterior occlusion. So I think it causes us to maybe have to do some occlusal equilibration that I think we should have to do. Sometimes I think that we would not have to be doing this if we had braces on these teeth. I think that is probably the biggest thing. Also when you have a bridge it is hard to move that. With braces what we can typically do is put a bracket on just one tooth and just not be fiddling between three teeth that are connected. I mean we can pretty much get that bridge to move where we want it to. I feel like with Invisalign they do not move well even though that they say that these are staying together, it just seems to mess things up. So I think that highly restored patients are tough.

Any additional challenges for obtaining successful outcomes with Invisalign, other than what you have mentioned?

There are two things to Invisalign to make it to work. The one is the expertise of the doctor doing the Clin Check. If you do not understand how things are going to move and what attachments are necessary. The biggest thing is patient compliance. They have to wear them and some do not. I recently had a case where I was doing sequential distalization of the right side. So if you looked at his Clin Check which was pretty long, about 50 aligners long, the seven was moving and the six. Well he lives in New York and he came home over Thanksgiving and he did not get his wisdom tooth out which he was supposed to. His aligners, his upper aligners fit great except for his upper lateral wasn't tracking great, but he is still in a Class II bite. He went through all of that. He had space because I remember talking to him on the phone and he said that he had space so all of that space opened and closed and he is still in that same exact bite that he was in. So I asked, "did you wear your rubber bands?" and he was like, "not really." So all that went by. I opened space and closed space and he is exactly where he was. So whether that is because he did not get the wisdom teeth out or he did not wear his rubber bands with his aligners. I know that he was wearing his aligners because they fit. So I think that is kind of tough because Invisalign is not correcting those big bite discrepancies the way braces can. I think that the difference in that, and I did this for him, is occlusal plane change. With braces we think that we are getting this, but what we are really getting is this and when you change that occlusal plane it, corrects the Class II. So if we do not build that into Invisalign we do not get it. It just looks like that the Class II is not correcting without the rubber bands. Which it is not because it is really not doing this with braces either.

Any other additional challenges that you have come across?

I think there are a lot of ways to fool the system. Like when you have teeth that look like they are not tight enough and you can tell the system that we are going to do 0.1 mm IPR and then you are not doing that really. I think that extrusion of maxillary laterals is difficult. Sometimes they just do not want to extrude the way that we think they should even with the proper attachment on them. So those are sometimes tough and frustrating. I do think that it is getting better and better and certainly occlusions look better than they used to. You do not have a lot of people with those posterior open bite anymore which is great.

How do you believe patients define successful orthodontic treatment?

I think that the majority of them define it as straight teeth. And that is not even smile esthetics. We have some people that I know that are not treated in our office that have straight teeth and they think that is great, but their smiles do not look great. Well that is not all of it, straight teeth. You need decent function. Why would you go through all of that and not have good smile esthetics? I think that people think that it is successful if their teeth are straight, most of them.

Do you think that there is anything else that they look at other than straight teeth?

I think that some look at overjet. They do not want overjet. So I think that they think that is part of straight teeth. Overbite if they do not really notice much unless they came in and their dentist told them that that was their chief complaint, but I think that the majority is straight teeth and fix my overjet. I do not want my front teeth to stick out.

Do you believe that general dentists and orthodontists perceive treatment outcomes differently?

Yes, I do not think that the general dentist knows what to look at. They do not care about a Class II bite in an adult. They just want the teeth straight. They do not even tell their patients that they have a Class II bite. They do not even educate them that it is off. I have a general dentist that I work closely with and she will tell me to just straighten the teeth. When they are doing their prosthetic work they are all into anterior coupling and whatnot. When they have us doing the straightening of the teeth they want anterior coupling, but when they are doing it they are like, "if I am doing Invisalign then I am just straightening teeth." They do not get into fixing the bite so I think that they are just looking at straight teeth. They are saying I can make your teeth straighter. I can make your bite better, but not great. Some patients are happy with that, which is okay, I guess.

What do you think is the reason for this difference or discrepancy between the orthodontist and general dentist?

I do not think that they know how to fix the bite. I do not think that they have ever been educated to do it. I think that not all, but some I think that if they are doing the treatment they do not really have knowledge of tooth movement or how to fix certain things. They just say I am going to make your teeth straighter and the patients are happy with that. So it is really what the patients want. Giving the patient what they want is a big part of it. That is what the company is pushing, is giving the patient what they want. What they want is to not wear braces and they want straighter teeth and that is true about some patients, but it is not true about all. I think that the general dentist thinks, well I am

providing a service even if I am not getting them into a perfect function, the smile esthetics did not improve that much, they think well I provided a service.

Any other comments on that topic?

I think that they are picky about 12 year old molars when the orthodontist is doing the work. If we send it back and they are not aligned then we are going to hear it. Whether or not they do it for their own patients, I do not know, but I think that is one thing. We always lineup 12 year old molars, but my friends complain to me about other orthodontist that do not. That is a complaint that I hear a lot from dentists.

In your opinion, how do you believe patients feel about Invisalign treatment that is completed by a general dentist versus an orthodontist?

I do not think that they know the difference. I had a woman once that I know and I say, "oh, I see that you are wearing aligners." She said, "yeah, my dentist is doing it. I knew that you would notice." I always knew that she had crooked teeth, but she actually said to one of my friends later, "well I am really glad that my dentist is doing it because I have had a lot of crowns fall off and he can fix it right away." I was like seriously crowns should not be falling off from Invisalign. So obviously the crowns were not very good either. She is done and her teeth are not that straight, but she is happy. She had one snaggletooth and it is straighter, but not straight. I do not think that they know the difference. I think that they just think that these people do Invisalign. I do not think that they think this person is trained and this person is not. I do not think that they know the difference at all.

Do you think that any patients at all perceive a difference?

Yeah, there are some who know. They often know because they were treated by the dentist and they were not happy with it and then they realize, "oh, I should go to an orthodontist." Sometimes these online forums are helpful. Even the Invisalign support forum right now, I sometimes watch that and it is funny because all of these people get told all different things. There are times that you see on there, "oh, well I bet that he is not an orthodontist. You should be going to an orthodontist. I bet that he is just a general dentist." So you start to see some of those comments out there on these online support forms. So I think that is a good thing. Maybe those will help us a little bit to get the awareness out.

Do you believe that patients feel differently about each clinician group's ability to achieve a successful outcome with Invisalign?

I would say the majority, no. I think that they think it is a product. They think that we are just a middleman. I do not think that they appreciate how much effort goes in to setting up that Clin Check. I think that is our job to educate them about that and I do not know what the best way to do it is. I always try to say to people, well you know it is like golf. I can use the same golf club as Tiger Woods, but we are not going to get the same result. He is obviously a master at what he does and we are masters at what we do. Then people are like, "oh, yeah I see that." And then they are like, "oh, why is that person doing it?" Well why does an amateur go golf? Because they want to and that is it. It is what it is.

Do you think that patients have different levels of confidence for Invisalign treatment that is completed by a general dentist compared to an orthodontist?

I think that before treatment, probably no. I do not think that they know. And whether they go to a dentist or an orthodontist, I think that the ones that go to the orthodontist are probably educated by the orthodontist throughout treatment that they are experts in what they are doing. For example, we had a patient that said, my friend is getting Invisalign at her dentist but she wants her overbite corrected and he said that he cannot do that with Invisalign. I told her that mine was fixed so why can't she do it? Invisalign can do it she was telling her friend. So I think that kind of talk starts to get around a bit. But I think in general, no. Those who were treated by a general dentist think that their teeth are straight and as long as their chief complaint was addressed they do not care about the rest of it.

Any other comments on this general topic?

I think it is all a matter about who markets harder. Invisalign is going to market and they are not going to say orthodontist because they want everybody using it. If you have a general dentist that is marketing Invisalign like crazy, or even says I am a such-and-such provider of Invisalign. Even if they say platinum, people do not know what that means. It is not high, but people do not know that. A platinum ring is nice so it sounds pretty good. They do not know what the other levels are. So I think it is really unfortunately a matter of who markets harder.

Do you have any other comments, or anything else that you would like to mention before we finish here?

I think that you really have to learn how to use it and I think that it is going to be the way we are treating most patients down the road. I think that people are going to look back eventually and say, "oh my God. People used to put this metal stuff in their mouth and walked around like that for two years?" I really do. Unfortunately, I do not think that it is as rewarding from day-to-day. Maybe people think that it is. I hear orthodontist saying that my day is so much easier when I have half Invisalign patients because I do not have to do anything. But it is not as rewarding. I think it is more rewarding to sit down and say, oh yeah I really want to rotate that tooth. Invisalign is like, "oh, do they fit? Yeah, okay go." You kind of feel like, why do I really even have to be the one to check that? All you are checking at that appointment is do they fit. We give them all of their aligners at the beginning of treatment. To me it is not as rewarding. It is kind of like when you were in dental school and it takes you a long time to set up for a partial denture. All of the little details like where your rest is going to be and to make sure that you cut your rest properly, the whole setting up. Then you give them their denture and they are done. Invisalign is kind of like that. You spend a lot of time on the Clin Check getting everything set up and then you give them their aligners and they are kind of done. Braces is not really that way. You see how the tooth responds and that is kind of the challenge throughout treatment. How is this tooth responding? You do not get that very often in Invisalign. I think that eventually it will really change our practices and we will sit here at the computer most of the time and text and our assistants will do the delivery of it. Why would we do that part? We are not going to have the same patient interaction

that you have now. The patients may be happy and there may be something in your practice that you do to go out and say hello to them, but they do not really need you during treatment other than the IPR and deciding whether you are going to take a new scan for refinement. For me it is not really as rewarding as it used to be because of it, but there are a lot of really happy patients that they got straight teeth without braces. Hopefully as it improves we can say that it does as good of a job as braces, which I still don't really think it does, like with deep bites. Open bites it does a great job. I think that is probably about it. I think that it is probably just a matter of mastering it and the product will keep getting better. All of the other ones that keep coming in will also keep getting better and better and then it will be just a matter of which one you choose.

APPENDIX F

DR. ALI HUSAIN TRANSCRIBED INTERVIEW

How do you define successful orthodontic treatment?

Well the definition is many-fold, but primarily the patient being satisfied with the outcome. And my personal goals, which hopefully coincide with the patient's goals, hopefully they are mutually agreeable, are to have a nice socketed in occlusion, Class I if possible. You know it's not always possible based on their skeletal discrepancy. A symmetric midline to the upper lip and facial midline and a nice smile arc so when they smile they show a nice upper incisor display. That's my primary goal. Then all of the other six keys that we are familiar with are obviously important. But the most important is getting the upper midline on and a nice smile arc and nice balanced esthetics.

If you had to pick one single parameter amongst everything, what would you choose?

The upper incisor display.

Is there any one factor that you think contributes the most to a successful outcome?

Would you say it is that or anything different?

There are so many factors, but I would say tooth size and morphology would dictate a lot of the ultimate esthetic outcomes.

How about factors that are in your control? What would you say is the most important then?

Factors that I can choose?

Factors that you can control in your hands as the orthodontist.

For me, control wise, is to make sure I have a nice smile arc.

For the first case, what do you like best about this case in general? Why did you pick this case?

I like this case, from a pre-treatment point of view, because she is an adult and has more spacing and mild to moderate crowding. I felt that she was a good candidate for Invisalign and her malocclusion was relatively minute. I treated her children so I thought that she would be a compliant patient and would be amenable to Invisalign.

For this case, what do you like the best about this particular outcome?

I think that she has nice posterior interdigitation for the most part. I mean certainly there are some exceptions to the second molar intercuspation. The torque can be improved. For sure that can be an area of improvement. Then there is perhaps some malalignment of the incisors, but more minute. To me it is more incomplete Class II correction and then incomplete settling of the second molars.

If there was a single parameter that you could choose that you like the best for this case, what would you say it is?

It would be posterior interdigitation.

If you had to pick one thing that you like the least about this case, what would it be?

The second molar contacts.

Anything other than that that you would have perhaps done differently for this case?

Now that I am looking back at the case, I would have probably added more lingual torque on the upper second molars just to ensure that those are in better contact. That is pretty much it. Everything else I think would be acceptable clinically.

We can move on to the next case then. Tell me about this case. Why did you pick this case?

So this case it is a little more complicated case. She is an end on end Class II. It is a pretty significant malocclusion more so on the patient's right. It is not too bad. It's a Class II on the right. The left side is slightly Class II. So it is a mild Class II malocclusion. So again, another case if I recall it was an adult patient and the patient had a Class II Division 2 bite and I felt that the patient was amenable to Invisalign because again the malocclusion was mild to moderate and not severe. The occlusion was off less than two to three millimeters so I felt that that was a good case for Invisalign.

For this particular case, what do you like about the final outcome?

Well I like the upper incisor angulation. I think that looks pretty good. That is probably the best part of it.

Anything else that you see, in general, that you particularly like?

The midline is nice and coincident. And the bicuspid seats down pretty well.

So if the number one thing then, if you had to pick one that you like the best, would it be the upper incisor angulation?

Yes, the correction from the Class II Division 2.

Is there anything that you do not like about this case?

I do not like the posterior interdigitation, especially in this case the upper first and second molars. I see that the Class II was not corrected completely, whether that was a planning situation on our end or if the patient was compliant because when we set up the Class II correction, they set up the occlusion assuming that the Class II would be corrected and as a result of that, they over-expand the upper assuming that you would get more posterior distalization. If the patient is not compliant, then you end up with this buccal overjet. So it is kind of iatrogenic because we set it up, but if the case or patient did not deliver or they did not respond. So it is either compliance or a biological response as an adult that we could not get that skeletal change. So we end up with a compromised result. The occlusion posteriorly is kind of a failure.

Is there anything else that you perhaps do not like about this case other than the posterior occlusion?

Just the posterior occlusion. Overall, it is a fairly good result.

Is there any different way that you would have treated this patient, or anything that you would have done differently?

Yes. If perhaps when I observed poor compliance with the elastics, I would have stopped the elastics and reset the case up with more posterior lingual torque to establish a better intercuspation in the posterior given the limitations of the case.

We can go on to the third case. Any reason in particular why you like this case and chose this case?

I chose the case because the patient has a severe skeletal asymmetry and a cant. It is not really a good, ideal Invisalign case. It would be better treated with braces, but the patient was adamant that he not be treated with braces and insisted on being treated with Invisalign. So we said okay we will give it a try. This is an old case treated before Invisalign was as good as it is now.

For this case, what in particular do you like about the outcome of this case?

I like the cant correction. That was my favorite part of the case. Being able to jump the anterior cross-bite and getting the cant nicely corrected. That to me was success, but in terms of failure, can I go to that?

Sure we can do that. What do you not like about this outcome?

As a result of the anchorage required to extrude the upper left segments, including the upper left 1, 2, 3, 4, 5, I had to use the molars as anchorage to push off against and as a result of that, the upper molars are intruded and with a little bit of an open bite on that side. So it is kind of a compromise. I tried resetting the case to then go back and move those teeth down, but the patient again could not come in and was not very compliant and did not want to go for that last move and he was happy with the result and said, "okay I am done." I could not get him in to do that final change, nor do I think it was an easy change with Invisalign because if I had to retreat him now I would take his aligners and cut out buttons for all four teeth, molars, and put settling rubber bands with sectioned aligners. But the fact is that it may have settled by now. To me that is the only thing that is incomplete.

Anything else other than the posterior occlusion on this case that could be more ideal or more perfect?

No, that is the main thing. The midlines are coincident. The teeth are fairly well aligned. It looks like there may be some residual spaces between the upper left three and four. It looks like there is maybe some incomplete rotational correction on the lower incisors, so for the most part it is a good result. There are some errors or areas of incomplete correction.

Just to summarize, what you do like about this case? Is there anything other than the cant correction or the anterior cross-bite correction that you like about this outcome?

That would be the primary one, the cross-bite and the cant correction.

We can move on to the last case. Why did you select this case?

So this is a tough one. This patient had severe crowding top and bottom. Wow, severe severe crowding case not so amenable to Invisalign due to the severity of the malocclusion and the lingually positioned incisors. That would be difficult to manage in terms of torque. It is an adult patient and most adults opted not to go back into braces.

What do you like about the outcome of this case?

I think that for the most part we have a nice alignment of the upper and lower anterior teeth. It is certainly not perfect, but is much better than what the patient presented with. We have a fairly good intercuspation of the posterior teeth. There is some residual buccal open bite on the upper first and second molars with excess buccal crown torque. My lesson learned from treating these cases is that when you expand with Invisalign, even the smallest amount, you end up tipping and you iatrogenically end up bringing the palatal cusps down. So the trick is to secondarily go back and add lingual torque on the upper posterior. If you look at every case, you find that because you are expanding to avoid extractions in this case. That is something you do every day with braces, but we use a rectangular wire to bring the torque back in and you do not have that benefit with Invisalign. So I think that the expansion with the aligners in our quest for

non extraction can put us in a situation where we have to overcorrect the case. I think that a lot of these cases settle nicely. When they come back for retainer checks I often see that the posterior teeth settle nicely assuming that they are within reason. It is the anterior teeth that relapse. So that is basically it. I think that it is a good case. Certainly there are some improvements that can be made but most of the changes are in the posterior.

If you had to pick one single thing that you like the best about this case, what would it be?

Yeah, alignment and the resolution of the lower crowding.

Is there anything that you do not like about the outcome of this case? I know that you already mentioned the posterior molar occlusion.

Yeah, that would be the only primary failure is the molar occlusion.

Is there anything else that you see that you think can be more perfect or more ideal?

Is there anything else that you would have changed?

No, I really have to look at the case if I want to get picky. The patient had a diminutive upper left lateral incisor so that makes it a little harder to engage and does not always track as well. Overall, I think that it came out, in terms of alignment, pretty acceptable.

How does the initial complexity of a case influence your opinion on its overall success of treatment?

Initial complexity certainly is a huge factor with Invisalign in particular. Not that you can't deliver good results. You have to set the expectations, realistic expectations because for your adult patients they are observing your treatment during the process unlike with braces. Braces of course, they are anxious to get them off, but with Invisalign they are watching you while you are working so they can be more demanding and their expectations are higher. You have to set proper realistic expectations.

Does initial complexity change your opinion on how successful a case turned out?

It depends on the case, but not necessarily. If it is a case where I can take out a lower incisor or I can do a combination case for example. I do this routinely if there is a molar that is tipped forward. I put braces on that arch first and upright that and then go back and do Invisalign. Or I will do a Carriere and do Invisalign. I do not necessarily think that complexity could dictate you from having a great result with Invisalign. You just have to set up the case properly.

What do you perceive is the greatest challenge for obtaining a successful treatment outcome with Invisalign?

It's compliance. That is number one.

Are there any other factors that are more in your control other than compliance?

Well a really thorough education and spending time with the patient each time because if they do not really see the value of your time with Invisalign. It is so automated because they come in every 12 weeks, or however often you have them come in, and you can just have your staff hand them the aligners. Then they leave thinking why did they bother coming in here. They could have mailed it to me. So you have to make sure that when you see them, even if it is just brief you have to make sure that either the doctor spends time with them or at least the staff spend some time with them so that they see the value and that you are checking them thoroughly. They do not mind coming in, but they do not want you wasting their time. In that appointment you can remind them how well they are doing or not, hopefully they are doing well, and you can remind them how important it is to follow up with a case.

Are there any objective outcomes or measurements that you think are perhaps difficult to obtain or that are more challenging?

Can you explain that again?

Going along with the same question, are there any, maybe from a biomechanical standpoint, anything that you are trying to do with Invisalign that is difficult to obtain? For example, is an ideal overjet difficult to obtain? Is a Class I occlusion difficult to obtain? Anything in particular in that sense?

I think to me, obviously I feel more confident and comfortable with alignment meaning closing spaces and resolving crowding for the most part then I do with overjet

correction. Particularly Class II correction is the most unpredictable. I have had moderate success. You are treating an adult typically, so you are going to have less biological capacity or room to correct. So I think that is the least successful, in my hands at least, Class II correction.

Any additional challenges other than Class II correction?

Lateral incisors tend to be a challenge to track. So lateral incisors often will lose their tracking despite adding attachments. They can cause you to have to rescan a case.

How do you believe patients define successful orthodontic treatment?

Well I think they are buying into an experience. We measure our success primarily from Class I, interdigitation, socked in occlusion, and all these objective measurements based on a ruler. How is your curve of Wilson? How is your curve of Spee? That is kind of how we put it to a number. That is how we scientifically evaluate our finish. I think that it is a unique field because a lot of the case is related to their experience in your office and not necessarily equal to the treatment outcomes. You can have practices in the same community where one practice may have inferior results consistently, but because of the way they are treating their patients and how they are seeing them on time, and they are consistently friendly and communicating with the parents, and keeping them up-to-date, and being upfront with them with what they can and cannot do, they are going to have a better reputation in the community and a better practice. Even though they do not have a perfect Class I, which are super important for us, but I think that we ridiculously over value it. It has made space for Smile Direct Club

and all of these tertiary at home treatments. Patients are sick of being pushed, like you need this Class II to be corrected. I do not care what you want, this is what I want and this is what I was taught and if you do not follow these rules then go home. We do not want to see you. So we dogmatically treat our patients with these arbitrary rules of which many were described in the 1880's. So we continue to force our patients into these rules from the 19th century, but yet the public wants quick and the least painful as possible at a reasonable cost. That is what the market is telling us and because we are not listening, these third-party players are coming into place. So we have done it to ourselves.

Are there any objective outcomes that you think patients value the most? Whether it be Class I, or overjet, or smile esthetics?

I think smile esthetics are number one. Especially my typical adult they are obviously looking closely. They want to have a nice coincident midline and good smile esthetics in the upper arch particularly. Everything else is obviously important, but that is the number one. Smile arc and nice anterior alignment.

Have you noticed anything else that patients in general really care about or value highly?

Well number one would be their chief complaint. That is why they came to see you, so treat the problem. With adults particularly you have to compromise some cases which is frustrating to us because we want every patient to walk out of our office with amazing occlusion and smile and when you cannot deliver that it affects us.

Do you believe that general dentists and orthodontists perceive treatment outcomes differently?

I do. I believe that general dentists think that we keep the braces on too long and we are not very cognizant of hygiene and decalcification and because we are so passionately seeking this Panacea of occlusion, that we can lose sight of decalcification and inflammation and periodontal disease. So I think that they think we are just so far removed from general dentistry that we lose sight of that. We are so worried about straight teeth that we forgot the big picture.

How about when you compare an orthodontist versus a general dentist doing orthodontic treatment? Do you think that they value things differently in terms of treatment outcome?

I think that because no one is looking after their work except them, I think that they are more realistic in their outcome and they are not going to try to make any occlusal correction. They are just going to work on alignment and facilitate their restorative care and periodontal treatment which is reasonable. If you have an adult patient, they just want to floss. They want to have clean teeth. They are not necessarily looking for occlusal correction.

In your opinion, how do you perceive patients feel about Invisalign treatment that is completed by a general dentist compared to it being completed by an orthodontist?

Well unfortunately I do not think that they know the difference.

Have you come across any patients that do know the difference?

Yes, I have had patients that have come in from the general dentist that have to be retreated and we take care of it for them. I think that once we educate them they do. We work with each other. We are all on the same team, so it is what it is.

Do you believe that patients feel differently about each clinician group's ability to achieve a successful outcome? Do they think that one group is perhaps better than the other?

I do believe yes. I believe that patients, for the most part, we have been around long enough as a specialty that the average patient that is middle class or upper middle class that can afford orthodontic treatment are probably educated about it. I think they do for the most part. The ones that fall in the gray area are some of your older adult patients who are over 50s where orthodontics wasn't as prevalent. They do not have as much of a relationship with orthodontics.

Do you have an opinion on what you think their opinion is on the difference between the two groups in terms of ability?

I like to think that most patients understand that they go to see their orthopedic surgeon to get surgery, not their general doctor. They kind of get that there is a dermatologist. So I think there are enough specialties in medicine that for the most part they understand the difference.

Do patients have different levels of confidence for Invisalign treatment that is completed by a general dentist compared to being completed by an orthodontist?

I would say yes, if they see us. If they are already in a general dental practice and they have a good relationship in that practice then it kind of makes sense. The general contractor does everything else so let them do my flooring too. I know he is not a flooring contractor, but he did a good job putting my walls up. There is a good relationship already built so unless the patient seeks us independently there is understandably a relationship and a trust built with the general dentist so it is understandable.

Do you have any other general comments about anything that we discussed, or anything that you would like to add, or any closing remarks?

Invisalign is a great modality for the right patient. I think that it can be overly prescribed because of the ubiquitous marketing efforts. I think that it is very expensive for the practitioner and it hurts the bottom line. So I think that for those practices that are big enough that they have the capacity or the excess capacity where they can take those patients and free chairs up because they are so busy and are at 100 percent capacity, and yes they should carve off those chairs. The 95 percent or something orthodontic practices which are not at capacity, it is still not necessarily a financially fit product for the patient and it has become more expensive for the provider and it has a downstream effect on the patient because the orthodontic office has less profitability and they can invest in less and less technology. It is not something they feel immediately, but over time the practice feels that. They have less room for hiring staff. So it has to be managed judiciously.