

**A QUALITATIVE ASSESSMENT OF INVISALIGN® TECHNIQUES THAT
EXPERIENCED CLINICIANS EMPLOY TO MANAGE EXTRACTION,
VERTICAL, AND TRANSVERSE PLANE DIFFICULTIES**

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By
Jordan S. Cogan, DMD
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Thesis Approval(s):

Orhan C. Tuncay, DMD
Thesis Advisor, Temple U. Kornberg School of Dentistry, Dept. of Orthodontics

Jeffrey H. Godel, DDS, MS
Committee Member, Temple U. Kornberg School of Dentistry, Dept. of Orthodontics

James J. Sciote, DDS, MS, PhD
Committee Member, Temple U. Kornberg School of Dentistry, Dept. of Orthodontics

ABSTRACT

Objectives: Qualitative research is a standard research method in social sciences. It elicits the opinions of studied individuals to understand the issues to be solved. Findings commonly lead to hypotheses for subsequent studies. In medicine, it has been utilized only sporadically despite arguments to understand quality of life of patients. We applied the phenomenological qualitative research method to understand the thought process of distinguished Invisalign practitioners. In the absence of experimental evidence, clinicians typically rely on their past clinical experience, opinions of experts, and limited published case studies. In an effort to develop a more robust knowledge base to build clinician skills, this study was designed to assess how expert clinicians address the divergence between ClinCheck[®] simulation and actual tooth movements with Invisalign.

Methods: Structured, open-ended interviews were conducted with five orthodontists who are known Invisalign experts of complex cases. Information were collected on: their approach to difficult transverse, vertical, and extraction treatment. Interviews utilized the conventional qualitative research protocol of recording, and then transcribing to analyze the data.

Results: Some experts seek to push the limits of the aligner appliance whereas others still rely upon auxiliaries, such as fixed appliances, to achieve the treatment goals. In extraction treatment, the difficulty of tipping and root paralleling were counteracted by designing ClinCheck with virtual Tweed mechanics, where the plastic and attachments create “couple” type forces. Constricted arches receive expansion of $\leq 3\text{mm}$, coupled with

flattening of curve of Wilson by buccal root torque of approximately 5-10°. Open-bite treatment relies upon intrusion of molars and “relative” extrusion of incisors whereas, deep-bite receives overcorrection with premolar extrusion to level the curve of Spee.

Conclusions: The expert orthodontist’s faith in Invisalign attachments, over-correction, and efficacy of virtual mechanics in ClinCheck are influenced by the malocclusion and their previous experience. Some experts seek to push the limits by re-configuring mechanics of the aligner appliance while others rely upon auxiliaries and braces to improve predictability. Hypothesis-driven experimental studies may now be designed.

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CHAPTER 1

INTRODUCTION

Once novel, Invisalign is now a digital orthodontic appliance used to treat millions of patients. This customized appliance is created by the aid of sophisticated 3D imaging and animation tools that enable virtual simulation of tooth movements. Tooth movements resemble a filmstrip, and each frame is called a stage. Each stage corresponds to a set of clear plastic aligner trays. As the trays are worn by the patient, every tray pushes the teeth .25-.33mm at a time (Tuncay 2006). Each tray or aligner is composed of clear, removable polyurethane, which provides esthetic and more comfortable appliance wear experience than the traditional fixed appliances. This unique and esthetic alternative to tooth movement continues to recruit more patients to orthodontic therapy.

As the demand for this treatment modality increases, so do questions of its efficacy. The weakness of this system and software is that it assumes tooth movements in the patient will mirror the virtual treatment. It hardly happens. Yet, some clinicians are very successful in producing the desired result whereas, the rest of the world is disappointed. A prospective clinical study evaluated the efficacy of tooth movement with Invisalign early on. The investigators studied the amount of tooth movement predicted by ClinCheck to the amount achieved post- treatment (Kravitz, 2007). The discrepancy of tooth movements between the actual patient and the virtual image created, had a mean fidelity of 41% for all tooth movements (Kravitz, 2007). This demonstrated the common necessity for midcourse correction or conversion to fixed appliances in order to achieve treatment goals.

The collusion of treatment goals and final treatment results can be evaluated in many different ways and can be quite subjective in nature. Utilizing the American Board of Orthodontics objective grading system, one study compared the treatment results of Invisalign patients to conventional fixed appliance patients (Djeu, 2005). Cases treated with Invisalign had mean scores of 13 points less, along with a 27% decrease in passing rate than those treated with conventional braces (Djeu, 2005). This implied that treatment results with traditional fixed appliances are superior to those of Invisalign.

Despite the apparent meager efficacy of tooth movement and mediocrity of Invisalign in comparison to conventional braces, malocclusions with mild to moderate crowding or spacing has long been known to be treated successfully with Invisalign. The first university based clinical study of Invisalign reported successful results of treatment with crowding or spacing of 3-6 mm (Boyd, 2000). The more complex malocclusions that require expansion, sagittal correction, and vertical discrepancies, however, make treatment with Invisalign significantly more challenging. Premolar extraction is one of the most common treatment modalities in orthodontics utilized to aid the clinician in addressing these more complex malocclusions. Control of teeth adjacent to the extraction site while closing extraction spaces is important in the prevention of the adjacent teeth tipping into these spaces. Upon examination, the teeth adjacent to premolar extraction spaces during space closure demonstrate that treatment with aligners can result in significant dental tipping, rather than bodily movement (Bollen, 2008). Yet, some clinicians have demonstrated the ability of Invisalign to close extraction spaces with new designs and dimensions of the attachments utilized (Boyd, 2001; Tuncay, 2016).

Despite the many advances in the Invisalign system, software, and research, there still lacks a complete understanding between virtual simulation and clinical reality. Thus, clinicians who plan to use clear aligner therapy must rely on their past clinical experience, the opinions of experts, and the limited published “evidence.” Where and how does the “clinician expertise and experience” come into the picture? It is not known. In the face of uncertainty, it is important for a clinician to learn the techniques to produce the desired outcome, and also the limitations of appliance manipulation. Accordingly, the aim of this study is to minimize the gap between the virtual and in vivo tooth movement.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Efficacy of tooth movement with Invisalign

Align Technology first introduced Invisalign to the market in 1999 after recent advances in digital technology enabled the creation of sequential removable aligners to move teeth. In 2002, with consultation from Align Technology, Bollen et al. designed a random clinical trial to determine how the frequency of aligner change and stiffness of material effected orthodontic treatment. Only fifteen of the fifty-one (29%) completed their initial series of aligners, and all those that did complete their initial set, had either an additional refinement or fixed appliances to complete treatment. The study concluded that subjects with a low degree of deviation from normal alignment and occlusion, and no extractions, were more likely to complete their initial series of aligners.

Questions continue to remain about the efficacy with which Invisalign can move teeth. While Align Technology purports that only a small fraction of patients will require a mid-course correction or refinement in order to achieve the treatment goals, orthodontists experience a majority of patients actually require a midcourse correction, refinement, or placement of fixed appliances in order to achieve those goals. In 2007, Kravitz et al. studied the efficacy of tooth movement with Invisalign more precisely by evaluating specific tooth movements. In this prospective clinical study of 27 patients, the predicted tooth positions of 401 anterior teeth were superimposed over the virtual model of the achieved tooth position. Expansion, constriction, intrusion, extrusion, mesiodistal tip, labiolingual tip, and rotation were evaluated. The mean fidelity of tooth movement

was 41%, with the most accurate movement being lingual constriction (47.1%) compared with labial expansion (40.5%). These data suggest that Invisalign can achieve greater accuracy in closing anterior spaces than alleviating crowding with just expansion alone. Ultimately, this may lead the clinician to consider interproximal reduction (IPR), rather than expansion and proclination. The least accurate tooth movement was extrusion (29.6%). The authors attributed the difficulty encountered with extrusion to the aligner poorly grasping the tooth during vertical pull. This may lead the clinician to prescribe overcorrection, attachments, or auxiliaries for even the most minor extrusive movements. Anterior intrusion, and therefore the correction of a deep overbite, also proved to be a difficult movement with Invisalign, with a mean fidelity of 41.3%. Additionally, the authors concluded that there is still much to learn regarding the biomechanics and efficacy of the Invisalign system and the importance of clinicians to fully recognize its limitations.

Krieger et al. performed a similar version of the study in 2012, comparing the pre-treatment and post-treatment casts to ClinCheck images of 50 patients. Parameters evaluated were upper/lower anterior arch length, intercanine distance, overjet, overbite, dental midline shift, and the irregularity index. The difference between the achieved and the predicted tooth movement was mostly minimal. All parameters were shown to be significantly equivalent except for overbite correction. Special attention, therefore, must be paid to correction of deep bite with aligners, a similar conclusion made by Kravitz et al. in 2007.

The previous existing comparisons are mostly limited to the anterior six teeth and provide only partial information about occlusal characteristics important to the evaluation

of orthodontic treatment. In order for aligner treatments to be valid and effective, the predicted and actual outcomes should be comparable in all segments of the dentition. In an attempt to evaluate the relative validity of aligner treatment, Buschang et al. in 2014, compared the ClinCheck model with the actual treatment outcome to determine whether overall occlusion and the various aspects of occlusion were comparable, utilizing the American Board of Orthodontics Objective Grading System (OGS). The authors concluded that the actual post-treatment models showed more deductions than the ClinCheck model for every component of the OGS. The vertical components of the OGS system, which include marginal ridges and occlusal contacts, displayed the largest difference between predicted and final outcome. This might be expected if moving teeth with aligners is more difficult in the vertical plane (Kravitz, 2009; Krieger, 2012).

In an attempt to summarize and combine the evidence on the efficacy of clear aligners, Rossini et al. conducted a systematic review in 2015 of eleven relevant articles. The outcomes assessed in this study were intrusion, extrusion, rotation, tipping, and overall alignment movements. Similar to Kravitz et al. in 2007, the authors concluded the extrusion was the most difficult tooth movement achieved with clear aligners (30% predictability). Contrary to the findings of Kravitz et al., however, this review concluded that anterior intrusion movement is not only achievable, but comparable to that reported for the straight wire technique. Other conclusions include the ineffectiveness to control rotations, but the effectiveness in distalization of maxillary molars by bodily movement of 1.5mm. The authors stress the ability of the clinician to employ auxiliaries such as elastics, IPR, and attachments, in order to improve the predictability of orthodontic tooth movement.

Obviously there are problems that need to be investigated as authors keep publishing these sorts of studies. A common theme consistently throughout the literature and practice is teeth not following the predicted tooth movements with Invisalign. Complete tracking of teeth is critical for the aligner's performance. Oftentimes, however, the non-tracking tooth is not to blame, but the adjacent tooth instead (Tuncay, 2017). All moving teeth require adjacent teeth to get out of their way. Accordingly, it may be wise for the clinician to extend tray wear or decrease the amount of tooth movement in each aligner (Tuncay, 2017).

The reasons for these frustrations with clear aligners are multifactorial. Until Invisalign is able to account for all its limitations, the next logical step was for clinicians to develop adjunctive techniques to improve the predictability in producing desired results. In contrast to traditional fixed appliances, compliance is the single most important factor in treatment success with clear aligners. Soluble, color-fading compliance indicators, therefore, were created as a policing device (Tuncay, 2009). Bowman cautions, however, that their effectiveness in eliciting cooperation is still in question. A multitude of other adjuncts, as well, have been developed in an attempt to maintain tracking including, but not limited to, aligner chewies, detailing pliers to create dimples and torque ridges, and "bootstrap" mechanics to help with extrusive movements (Bowman, 2017). It is evident that the present Invisalign appliance requires a variety of concepts and methods to enhance the clinical fidelity and efficiency of treatment.

Much of the research focuses on the ability of Invisalign to achieve tooth movement with disregard to the broad principles of orthodontic tooth movement. Currently, Invisalign's staging algorithm provides the maximum velocity to the portion of

the tooth moving the most, whether that is the crown or the root (Morton, 2017). When it is the root that has the most movement, a virtual root projection is created based upon averages (Morton, 2017). The magnitude and direction of force placed on teeth during orthodontic tooth movement, however, in addition to length of time and variability among patients, also play critical roles. ClinCheck software attempts to account for force applied to the tooth, but fails to account for age, sex of the patient, and bone biology. As Chisari et al. in 2014 points out, despite planned movement of .25mm per aligner, on average, only 57% of that movement was achieved in part due to the variability in age and sex of the patient. The combining of data learned from the database of tooth movements, from understanding mechanics of clear aligners, and the experience of clinicians, as well as technology such as CBCT, are destined in the future to change the staging algorithms and therefore, the efficiency of tooth movement with Invisalign (Morton, 2017).

2.2 Treatment of sagittal discrepancies with Invisalign

2.2.1 Extraction treatment

Boyd et al. published the first case reports with the Invisalign system in 2000. The four patients described had relatively uncomplicated malocclusions involving mild-to-moderate spacing or crowding (3-6mm). All four patients displayed good results opening a new way of treatment for patients who did not want conventional fixed appliances. Boyd et al. in 2001, in a follow up to the previous case series, evaluated the treatment results for subjects with more complex malocclusions, including extractions. The authors

concluded that in cases of premolar extraction, the appliance caused teeth to tip into extraction spaces, especially when there were short clinical crowns or mesial movement of posterior teeth requiring more than 2mm. The use of 5mm long, rectangular, vertical attachments, however, helped to correct this limitation.

To control tooth inclination is particularly important during the closure of extraction sites due to the tendency for the crowns of adjacent teeth to tip into the space. As previously mentioned by Boyd in 2001, clear aligner therapy with Invisalign was not especially good at controlling this tipping. Baldwin et al. conducted a study in 2006 in an effort to specifically examine the ability of aligner appliances to control this dental tipping into premolar extraction spaces during space closure. Their sample consisted of a subset of 24 subjects who took part in a randomized control trial of the Invisalign system. Subjects had at least one premolar extracted as part of their treatment. Ovoid or rectangular shaped attachments were used accordingly as designed by Invisalign ClinCheck software. Contrary to Boyd et al. in 2001, these attachments did not help to correct this limitation, as treatment with aligners resulted in significant tipping of the teeth adjacent to the extraction site.

Although this study clearly showed that teeth adjacent to the extraction site experience tipping with Invisalign, it did not exclude the possibility that aligners can produce translational movement. Different size and shape of attachments are now recommended to perform these kinds of movements and can provide different results. In 2006, Womack clearly demonstrated the ability of Invisalign to successfully treat a four-premolar extraction case. Key to his success was minimal required mesial movement of

posterior teeth (<4mm), specific attachments to help with tooth movement (5mm long, 2mm wide and 1mm thick), and perfect patient compliance.

More recently, Li et al. demonstrated this in a randomized control trial in 2015, in which they assessed the treatment outcomes of Invisalign results with fixed appliances in Class I adult extraction cases using the American Board Association (ABO) grading system. In evaluation of post treatment root angulation, there was no statistically significant differences between the fixed and removable groups. The authors attributed this finding to the correct implementation of attachments to control root movement. In addition to root angulation, the overall orthodontic grade as determined by buccolingual inclination, occlusal relations, alignment, interproximal contacts, marginal ridges, occlusal contacts, and overjet, increased in both Invisalign and fixed appliance treatment indicating the ability of Invisalign to be equally successful in treating Class I extraction cases.

In essence, the successful space closure in extraction treatment with Invisalign lies within the prevention of tipping (Tuncay 2017). Tuncay recommends allowing the plastic to surround the tooth in a “cupping” manner mesially, distally and buccolingually to prevent or minimize tipping. Accordingly, space both mesial and distal to the tooth should be made available on the ClinCheck with the aid of sequential movements rather than en masse (Tuncay, 2015). The clinician must also understand that during premolar extraction treatment, as the anterior teeth are retracted, the aligner length decreases (Tuncay, 2017). This decrease in length may ultimately place a mesial force on the molars. If the plan is to hold the molars in place, special precaution must be taken (Tuncay, 2017). Tuncay recommends rectangular attachments that are 5mm long, 2mm

wide, and 1.5mm prominent, as the optimized attachments seen on ClinCheck do not prevent this unwanted tipping.

Since its induction in 1999, evident is Invisalign's vast evolution through the years. The product has advanced substantially from treating simple Class I malocclusions to treating multiple extraction cases. An article by Chan and Darendeliler, published more recently in 2017, highlights its progression, claiming Invisalign as a "thinking person's orthodontic appliance." Both specialist orthodontists, they took time to perfect the system through the utilization of smart biomechanics in order to bypass the inadequacies of clear aligners. After years of experience, the authors conclude that treatment progress is not as easy and predictable as the computer animation dictates. In extraction treatment specifically, not only good and sufficient attachments need to be selected, but compensatory movements need also be planned (Chan, 2017). For example, there is a need to increase upper anterior lingual root torque and intrusion of lower incisors to prevent the "dumping" effect created during the closure of extraction spaces. Similar to Tuncay, the authors stress the need to prevent the tipping into the extraction space. Increase in root tip movements into the extraction space is, therefore, needed to counteract this phenomenon (Chan, 2017). Managing extraction cases with Invisalign is certainly not easy. It is the clinicians understanding of the side effects and inadequacies of the aligner system that is extremely important in the treatment of these complex cases.

2.2.2 Non-extraction treatment

The manufacturer of Invisalign claims that Invisalign can effectively perform dental movements including space closure, alignment, expansion, and distalization.

Nevertheless, the case selection criteria of Align Technology are guidelines and are not restrictive. Align Technology defers to the clinician's professional judgment in determining how Invisalign can be utilized. In 2005, when Djeu et al. completed an outcome assessment of Invisalign and conventional braces, Invisalign did not generally recommend treating more complicated malocclusions with anteroposterior corrections of greater than 2mm. In an effort to assess treatment outcomes and ability of the Invisalign system, the authors utilized the objective grading system (OGS) used by the American Board of Orthodontics. While Invisalign and traditional fixed appliances had similar scores on alignment, marginal ridges, interproximal contacts and root angulation, braces had significantly superior scores for correcting buccolingual inclination, occlusal contacts, and more importantly, occlusal relationships and overjet. Particularly important to the outcomes of Invisalign, the authors conclude, is the proficiency in using the ClinCheck software and the ability of the practitioner to accept or modify the treatment plan of tooth movements.

Some users doubt the ability of Invisalign to achieve bodily movement and recommend clear aligners only when tipping movements are needed (Baldwin, 2006). In the years following, in order to address the treatment of these more difficult malocclusions, Align Technology has developed several advances including different attachment designs and auxiliaries, such as Precision Cuts and Power Ridges. Among clinicians, one very important question, still relevant, is if and to what extent anterior-posterior movements can be performed using Invisalign. This capability would significantly increase its indications.

Consequently, Simon et al. in 2014 conducted a study to investigate the ability of Invisalign to achieve molar distalization of greater than 1.5mm. Without the use of Class II elastics, the authors were able to achieve an accuracy of 87% in molar distalization with maximal tooth anchorage, as no anterior teeth were moved during distalization. The authors conclude that the impact simultaneous tooth movement has on the overall efficacy of distalization or the use of interarch elastics in enhancing distalization remains to be investigated.

When it comes to the decision on whether the Class II malocclusion should be corrected with molar distalization or elastic simulation, a strong understanding of the growth potential of the patient is important (Chan, 2017). The default staging pattern for correction of the molar dental relationship is “sequential” tooth movement. The terminal tooth is usually distalized as stage 1 for approximately 8 stages prior to movement of the following molar (Chan, 2017). Chan and Darendeliler argue that although this staging pattern is predictable in non-growing patients, it usually prolongs treatment. The authors suggest utilizing Class II elastics, along with sequential staging, in order to reduce treatment time and improve predictability.

In order to further reduce treatment time, en masse distalization can be prescribed. Right from the commencement of treatment, the whole arch distalizes to achieve the A-P correction. This staging pattern does not come without its hiccups as clinical tracking becomes more difficult (Chan, 2017). Chan and Darendeliler stress the importance of checking the fit of the aligners at each adjustment and evaluating maximum intercuspation, allowing the clinician to adjust anchorage control as needed with Class II

elastics. Patients most suitable for this sequence are non-growing, adult patients with up to half unit AP correction needed (Chan, 2017).

Class II elastics in conventional fixed orthodontic treatment is the norm, especially in growing children. As more adolescents seek Invisalign treatment, elastic simulation staging pattern is becoming increasingly more popular with aligner treatment as well. This staging pattern has proved to be effective in achieving AP correction of up to half a unit in growing patients (Chan, 2017). The success of treatment, however, does rely heavily upon the severity of the Class II, growth potential, and patient compliance (Chan, 2017).

Using preset defaults in the ClinCheck software and the technician's recommendations may allow the new clinician to easily treat Class I malocclusions. Apparent is the importance of orthodontic biomechanics and, more specifically, how those principles relate to the Invisalign appliance when faced with more complex malocclusions, such as AP correction.

2.3 Treatment of vertical discrepancies with Invisalign

2.3.1 Deep Overbite Treatment

Orthodontic treatment of patients with more complex malocclusions requires correction of vertical discrepancies of the dentition, including both open bite and deep overbite relationships. In one of the earliest university based clinical studies that investigated treatment of complex malocclusions, Boyd and Vlaskalic in 2001 concluded that correction deep overbite is one of the most predictable movements with Invisalign. In

their case study, the deep overbite was corrected primarily through labial tipping and intrusion of anterior teeth.

A unique advantage to Invisalign in deep overbite treatment is the disclusion caused by the aligners. The disarticulation promotes the avoidance of any interference, while it allows immediate treatment of both maxillary and mandibular arches on “day one” of treatment. Deep overbite treatment requires, to some degree, molar extrusion, incisor intrusion, or both. Careful assessment of incisor display is required in order to determine which approach is most appropriate. Giancotti et al. in 2008 demonstrated the ability of Invisalign to resolve vertical discrepancies in three separate cases mostly by leveling the curve of Spee in conjunction with some maxillary incisor intrusion, without impacting the smile arc.

As with any treatment planning in orthodontics, an understanding of the etiology of the deep overbite is important. It is for this reason that Align Technology, in conjunction with Dr. Jonathan Nicozisis, believes that correcting deep overbites has evolved from thinking it was a clinical impossibility to a predictable clinical challenge, provided it is designed properly in the ClinCheck software. In his technique to leveling the curve of Spee and resolution of the deep overbite, Nicozisis recommends extruding the lower bicuspid at a rate of .15mm per stage for a total of 3mm and by intruding the lower cuspid a total of 4mm. In addition, the recommended attachments are horizontal, rectangular, beveled gingivally and placed as far occlusally without any interferences. The author stresses the importance of incorporating corrective mechanics utilized with fixed appliances as you design your ClinCheck to ensure success (Nicozisis, 2012).

2.3.2 Anterior Open Bite Treatment

Orthodontic treatment of open bite remains as one of the most challenging problems facing orthodontists today. Orthodontic intervention with the plan to extrude anterior teeth and intrude posterior is most appropriate where dentoalveolar open bite maybe treated orthodontically rather than surgically. Useful in the treatment of anterior open bite, intrusion of the posterior teeth can commonly occur even without preprogrammed movement. Intrusion of the posterior teeth is due to the double layer of material between them, usually creating a total thickness of 0.06in (Boyd and Vlaskalic 2001). Therefore, with the intrusion of molars and no extrusion of the anterior teeth, a counter clockwise rotation of the mandible can occur to correct an anterior open bite successfully with Invisalign (Boyd and Vlaskalic 2001).

This technique of posterior intrusion has proved to be quite successful in the treatment of anterior open bites when indicated. So much so, Align Technology in 2011, in conjunction with Dr. Willy Dayan, provides the practitioner with the techniques for achieving posterior intrusion. These techniques include attachments on teeth adjacent to the teeth being intruded, utilizing chewies as an exercise 2-3 times per day for 15-20 minutes at a time, and planned elastics or IPR to adjust overjet as auto-rotation occurs (Dayan, 2011).

Contrary to previous literature, Guarneri et al. in 2013 demonstrated the ability of Invisalign to correct an anterior open bite of 4mm without intrusion of posterior teeth and a subsequent change in the mandibular plane angle. Instead, extrusion of the anterior teeth and resolution of the anterior open bite was achieved by utilizing beveled, horizontal, rectangular attachments 1mm thick on the gingival side and .25mm thick

towards the incisal surface. Whereas the available pertinent literature cites the difficulty to achieve extrusion with Invisalign (Kravitz 2007; Rossini 2015), the authors were able to achieve a successful outcome by utilizing different attachments and potential “expertise” in the manipulation of the Invisalign appliance.

Pure extrusion of incisors, or laterals more specifically, with aligners still proves to be difficult. It could be due to adjacent teeth influences, attachment design, or periodontal ligament special fibers (Tuncay, 2017). These can be overcome by manipulation of the Invisalign appliance including, but not limited to, force duration and attachment design. Tuncay stresses the need for the tooth shape to be changed to allow for the aligner to grip the tooth. Accordingly, if the attachment design is a rectangular 5x2x1.5mm type, the plastic can find surfaces to snap on to grip the tooth. It is important to note that any force must overcome the resistance of the soft tissue. It is for this reason that in order to produce more predictable tooth movement with the gentle forces of aligners, orthodontists must understand the characteristics of the periodontal soft tissues (Tuncay, 2017).

2.4 Treatment of transverse discrepancies with Invisalign

Arch expansion may be perceived as necessary with Invisalign in an effort to improve the esthetics of a smile, to correct posterior dentoalveolar crossbites, or simply a mechanism to create space for dental crowding. In their 2001 article on the treatment of complex malocclusions with Invisalign, Boyd and Vlaskalic stated that buccal expansion of 2-4mm could be achieved in order to provide space for anterior crowding or change the arch form. Furthermore, they determined that this expansion was mostly tipping in

nature. If bodily expansion was required, however, it could be achieved by overcorrection specified in the ClinCheck software.

With an overall scarcity of data on posterior transverse change with Invisalign, Houle et al. in 2016 investigated the predictability of arch expansion with Invisalign, comparing ClinCheck transverse measurements with the actual clinical outcome. The authors concluded that the mean fidelity of expansion planned with Invisalign was 72.8% for the maxilla and 87.7% for the mandible. In agreement with the findings of Boyd in 2001, more tipping was observed as ClinCheck overestimates the amount of bodily movement achievable. It is therefore appropriate to incorporate overcorrection of the required expansion. Most importantly, variance among the measurements conducted in both the maxilla and mandible were not equal, meaning the amount of change planned, according to ClinCheck, is not associated with any prediction error. Knowing the potential performance of the software to predict movement would help the clinician anticipate the degree of overcorrection needed and minimize the use of refinements.

In treatment of adult patients with Invisalign, skeletal expansion cannot be expected without surgical intervention. Dental expansion, with limitations, however, is predictable and successful with Invisalign according to Chan and Darendeliler in 2017. Cases with a thin biotype and recession should be avoided (Chan, 2017). Instead, the authors recommend select cases with lingually tipped buccal segments and a thick gingival biotype. Understanding the side effects of all tooth movements, including expansion, is necessary in order to design a successful ClinCheck plan. To counteract these side effects, vital when prescribing expansion in the ClinCheck software is intrusion and increased buccal root torque of the upper posterior teeth, appropriate

attachments to increase surface area contact, and over expansion of up to 20% of the desired distance (Chan, 2017).

The best approach to orthodontics is to first determine the desired outcome. Then, it is up to the clinician to design the appliance to deliver the force system that is required to obtain that desired result. The clinician is responsible for the treatment of the patient and the comprehension of strengths and weaknesses of the appliances at hand. Application of basic orthodontic concepts that maybe outside the clear aligner box will ultimately allow orthodontists to further the craft more, efficiently with Invisalign.

2.5 Qualitative (phenomenological) research method

Qualitative research is a newcomer in health sciences. The term “qualitative research,” means any type of research that produces findings not arrived by statistical procedures or means of quantification (Strauss 1998). In this type of research method, researchers will typically gather data by means of interviews and observations. The data, however, is not to be coded in a manner that allows it to be statistically analyzed. Qualitative research, is the nonmathematical process of interpretation, carried out for the purpose of discovering new concepts and relationships in raw data and then organizing these into a theoretical explanation (Strauss 1998). Qualitative methods can be used to explore substantive areas about which little is known, or about which is known in order to gain novel understandings.

There are three major components of qualitative research. First, there are the data. The data can come from various sources, including interviews, observations, recordings, and documents. Second, are the procedures the researchers can use to interpret and

organize the data. In order to interpret the data, the data must be coded. Coding is the analytical process through which data are fractured, conceptualized, and integrated to form theory (Strauss 1998). Finally, the third component is presented as written journal articles or verbal reports at conferences.

In this method, data collection, analysis, and eventual theory stand in close relationship with one another. The researcher does not begin with a preconceived theory in mind. Instead, the researcher begins with an area of study, and allows the theory to emerge from the data. This grounded theory is to provide insight, enhance understanding, and hopefully provide a guide to further action or further studies (Strauss 1998).

CHAPTER 3

AIMS OF THE INVESTIGATION

The purpose of this study is to evaluate and assess how experienced and expert clinicians address the divergence between virtual simulation and in vivo tooth movements with Invisalign. It is unknown where and how clinical expertise and experience comes into the picture to provide solutions and preventive measures with Invisalign. In our effort to answer this debate, the objective of this project is to extract information on the following clinical situations:

- Transverse discrepancies
- Vertical discrepancies
- Sagittal discrepancies

The expected outcome is a coordination of qualitative treatment data that provides insight into the treatment of these clinical situations.

CHAPTER 4

MATERIALS & METHODS

After receipt of an initial explanatory letter, the orthodontists agreed to participate in this study. They were subsequently interviewed at their practices. A structured, open-ended interview was conducted with each orthodontist to discuss his or her opinion on difficulties of transverse, vertical and extraction treatments with Invisalign. The questions were constructed to obtain qualitative data from orthodontists, using open-ended questions. The interview was recorded using a digital audio recorder and subsequently transcribed at their consent.

The sample consisted of five Orthodontists who are known Invisalign experts of complex treatment cases. The interviewer also collected data on their willingness and comfort level. The sample of expert clinicians is as follows:

1. Dr. Jay Bowman, an orthodontist for over 25 years in Kalamazoo, MI, is an award-winning researcher. Dr. Bowman has authored or co-authored over 100 articles and book chapters in orthodontics and was selected as one of four orthodontists in the U.S. for the Invisalign Teen Research Investigative Team.
2. Dr. Brian Amy and his orthodontic practice in Oklahoma City are ranked in the elite top 1% of providers of Invisalign in the United States, a designation given to those who have treated at least 800 cases and continue to perform 200 cases annually. He, also, serves as an international speaker and faculty member for Align Technology, the global provider of Invisalign treatment. Each year, Dr. Amy speaks to hundreds of orthodontists from around the world to educate, mentor and advocate for the Invisalign treatment options available for adults and

teens. He has participated in multiple research studies that have resulted in journal publications and advances in Invisalign treatment. This includes research on teen Invisalign, a member of the investigative team, evaluating patient oral health and satisfaction.

3. Dr. Jonathan Nicozisis is an orthodontist in Princeton, NJ, and a top 1% provider of Invisalign. He is also a member of The Invisalign National Speaker's Bureau and Clinical Research Network, where he helps conduct research and development of new technologies and improvements to the techniques employed by Invisalign. He has given over fifty national and international lectures, including lectures at the National Invisalign Summit Meeting for Orthodontics Specialists. Dr. Nicozisis was also selected as one of four orthodontists in the U.S. for the Invisalign Teen Research Investigative Team.
4. Dr. Ali Husain has been an Invisalign certified provider for over 15 years in the state of Delaware. Dr. Husain is a designated Elite Premier provider of Invisalign, placing him among the top 5% of practices in the United States.
5. Dr. Gerald Ginsberg, is a now a retired/ part-time faculty member at Temple University's Orthodontic Post-Doctoral Orthodontic Residency. Dr. Ginsberg has treated hundreds of patients with Invisalign, designating him as a premier provider of Invisalign in Delaware Valley, PA. Dr. Ginsberg is also recognized as a previous national Invisalign case competition winner.

After reviewing the transcribed interviews, recurring phrases and key words were identified and grouped (*i.e.*, coded) for types of complexities, solutions, and measures of

prevention. These words or phrases were grouped according to themes. Each theme was assigned a color. Using the assigned colors, applicable key words and phrases from the interviews were highlighted. This color-coding provided discrete patterns and a visual means of analysis. By observing coded phrases, observations and trends could be noted. Ultimately, such data was fractured, conceptualized, and integrated to form a theory.

CHAPTER 5

RESULTS

5.1 Qualitative Results

Responses to the open ended questions were coded based on key words and key phrases. Coded words and phrases were organized by predictably, discrepancy, and doctor. The raw data can be found in the appendix. The coded data table is displayed in Tables 1, 2, 3, 4, 5, and the appendix.

Data were compared between doctors to find similarities of extraction, transverse, and vertical plane treatment modalities with Invisalign to observe response trends.

5.1.1 Comfort and Predictability

Each expert Invisalign practitioner was asked to assess their comfort level with the appliance, along with identifying cases in which the ClinCheck software does not adequately predict reality. Similarities and differences between doctors were observed. Despite the varying degrees of comfort, similar cases were considered less predictable.

A unanimous factor that was considered least predictable in the success of ClinCheck simulation by expert Invisalign practitioners was patients requiring premolar extractions. Predictability of Invisalign, as defined by one doctor, is cases requiring more refinements. As described by the same practitioner, “Right now, the big thing I am working on, is making the four bicuspid extraction case predictable.” Meaning that he can get through the initial series of aligners without the need for mid-course correction.

Others see limitations of the appliance and “always look for ways to get around them” by use of auxiliary appliances.

Other factors that decreased the efficacy of the ClinCheck software included patients with extreme discrepancies: severe Class II/III malocclusions, severe vertical skeletal patterns, and severe transverse discrepancies. The Invisalign expert deemed to have the highest comfort level strongly also considered the age and periodontium of the patient when evaluating the divergence between ClinCheck and reality.

Currently, the orthodontists interviewed are managing patient expectations with these more severe cases. Whereas some “used to be very focused on the idea of difficulty level” with Invisalign, they now seek the right patient. The patient must be dedicated and understand that they will be taking multiple scans and dealing with hiccups accordingly in these challenging, less predictable cases.

Table #1. Qualitative Data: Comfort/Predictability					
	Dr. Nicozisis	Dr. Bowman	Dr. Amy	Dr. Ginsberg	Dr. Husain
Comfort	High	Moderate	High	Low	Moderate
Predictability	-four bicuspid extraction -age of the patient -skeletal pattern -Periodontium -age of the patient -skeletal pattern	-Case selection -severely crowded -extraction cases -Severe Class III or Class IIs -Severe open bites -Surgical cases	-cooperation -right patient -tipping problems -molar tipping -upright a molar -molar tipping	-four bicuspid extractions -tipping	-Severe canine rotations -severe brachycephalic cases -extractions -crossbite correction -rotations -torque -superior to braces in dental open bites

5.1.2 Extraction Treatment

Tipping and root paralleling are common challenges faced by the Invisalign doctor during extraction treatment. While different techniques are utilized, similar among those interviewed was the incorporation of preventive mechanics. One doctor mentioned, “The best way to deal with my ClinCheck treatment plan, is to think of fixed appliances.” Four of the five experts utilize these basic edgewise ideas by incorporating virtual gable bends into the extraction sites. This provides root convergence in the ClinCheck to counteract the desire for the teeth to tip rather than translate.

Two of the experts feel that tipping is not preventable with the Invisalign appliance alone. “Trying to get root paralleling is tough despite what claims are made for attachments.” In their opinion, it, therefore, requires anchorage in the form of miniscrews, finishing with fixed appliances, or other auxiliaries.

Manipulation of the ClinCheck software is commonly performed with over correction. No millimetric amount of overcorrection could be identified as the appliance is constantly advancing and experts heavily rely upon their previous experience. Important, however, is treating the software similar to that of fixed appliances in over treating or over correcting tooth movements in the opposite direction of the original problem. One expert clinician over corrects tooth movement in extraction cases by creating "freeway space." In the maxillary dentition, this consists of an exaggerated curve of Spee and a reverse curve of Spee in the mandibular dentition. This creates a posterior open bite in the ClinCheck simulation. As he describes, "You must think about what you are seeing in ClinCheck and how that translates to forces, so you don't see that freeway space clinically." Here, he is purposely creating a divergence between the software and

reality by intruding the molars 1.5mm and premolars 1mm, adding mesial root tip the posterior teeth, and anterior facial crown torque in his attempt to counteract the deleterious effects of space closure.

Some attempt to provide a greater push surface by enveloping the tooth with the plastic appliance, while others utilize attachment design. Both techniques seek greater control over tooth movement. Align technology provides optimized attachments for specific tooth movements or doctors can be creative in creating their own customized attachments to further optimize the movement they seek. Two of the five doctors utilize an optimized twin attachment on the canine to provide couple type forces in mesiodistal root control, while the others still prefer a more conventional long, vertical rectangular attachment. Some continue to seek innovation of their own. One expert practitioner has created his own "ying-yang" attachment for molars. This attachment is essentially a, "twin attachment on the cuspid flipped 90 degrees to fit the mesiodistal width of the molar" in order to provide couple type forces and more adequately control molar tipping.

Despite their many attempts at prevention, four out of the five orthodontists describe the occasional requirement of fixed sectional braces to obtain proper root parallelism. As one doctor describes, "The issues are almost always molar tipping. If you have to put a segment on, you're losing your advantage of treating faster." Patients are, therefore, commonly informed of the potential need for auxiliaries prior to beginning treatment in order to heed expectation. Most evident in this study of extraction treatment with Invisalign is the persistent challenge and prevention of tipping and obtaining root parallelism.

Table #2. Qualitative Data: Extraction Treatment					
	Dr. Nicozisis	Dr. Bowman	Dr. Amy	Dr. Ginsberg	Dr. Husain
Extraction:					
<i>Tipping/ Root paralleling</i>	<ul style="list-style-type: none"> -gable bends -torque the anterior teeth -intrude the posterior teeth -mesial root tip -intrude (molars) -ying yang -mesial root tip -intrusion (molars) 	<ul style="list-style-type: none"> -anchorage from mini screws -sectioning the trays 	<ul style="list-style-type: none"> -G6 protocol -gable bends -virtual -gable bends -gable bends -gable bends 	<ul style="list-style-type: none"> -no way to avoid it -slow movement -slow movement -move the roots first (gable) 	<ul style="list-style-type: none"> -converge at least 15-20 degrees -at least 20 degrees of labial crown torque on anterior teeth
<i>Overcorrection / ClinCheck manipulation</i>	<ul style="list-style-type: none"> -freeway space -freeway space -freeway space -freeway space -freeway space -freeway space 		<ul style="list-style-type: none"> -great push surface -greater surface -no specific amount (overcorrection) -over treatment -trust the software 	<ul style="list-style-type: none"> -1/10 of a millimeter per movement -no exact amount (root tip) -move teeth sequentially -cover the mesial surface -envelops the tooth 	<ul style="list-style-type: none"> -anterior torque -en masse (retraction)

Table #2, continued					
Attachment design <i>Align</i> <i>Customized</i> <i>None/ many/ not many</i>	-G4 twin attachment (cuspid) -G4 twin attachment (cuspid) -ying yang attachment (molar)	-Vertical rectangular attachment	-optimized attachment -optimized attachment -optimized attachment -optimized attachment	-5mm long rectangular attachments and 2mm thick vertically	-long vertical attachments -traditional long vertical attachment
<i>Auxiliary/ elastics/ braces</i>		-buttons and elastics -mini screws -sectional braces -mini screws -rubber bands -mini screws -rubber bands -mini screw elastics (rely on auxiliary or TAD over Invisalign)	-Segment (braces) -segment	-finish them off with fixed sectionals	-Buttons and power chain (with Invisalign)

5.1.3 Transverse Discrepancy

Skeletal expansion is not believed to be possible with Invisalign. If a true skeletal discrepancy exists, skeletal correction with either a Hyrax or surgery is recommended. All orthodontists in this study, therefore, limit expansion with Invisalign to 3mm or less having modest expectation in the realities of ClinCheck. They seek resolution of minor single to couple teeth cross bites by tipping. One orthodontist expressed his limitations stating, “If you ask for more than 3mm (of expansion), I am not sure you are getting it.”

These low expectations are guided by the same principles of fixed appliances. Anchorage units both mesial and distal to the offending teeth are utilized for correction. Constricted arches receive expansion with over correction by translation, torque, and intrusive movements.

Three experts rely on past visual experience when prescribing over correction of buccal root torque. One states, “I do not have measurements at this point, but I think it would be valuable to find out.” There are, however, some varying numbers reported by those interviewed. One practitioner prescribes approximately 5-10 degrees and the other almost 20 degrees. Regardless of the amount, consistent among all ClinChecks was an increased degree of buccal root torque where the root is beyond the crown. As a way to gauge the torque prescribed, one practitioner “makes sure there is less lingual surface visible on the 4, 5, 6 at the end of the ClinCheck when viewed from the occlusal.” In order to further flatten the curve of Wilson, increased buccal root torque in conjunction with intrusion of the palatal cusp is required. This acts to further counter some of the tipping that occurs with expansion. Intrusion of the palatal cusps is in fact “what is giving you your torque.”

Invisalign practitioners attempt to minimize the discrepancy between ClinCheck and reality by the augmentation of attachment design. Most commonly placed by three of the five interviewed are horizontal attachments beveled to the gingiva. This attachment, typical of extrusion, is utilized to keep a downward force upon the tooth as it is pushed laterally. This is in an attempt to negate the desire of the tooth to tip buccal. Others mentioned specific attachment design is of less importance and trust the software to give them the attachment needed, i.e. an optimized attachment. Beveled attachments on the

lingual, as well as the buccal, maybe utilized in trying to create couple type forces and subsequent buccal root torque.

No different than with fixed appliance treatment, auxiliary appliances such as a quad helix, hyrax, or cross elastics are commonly required for more severe transverse discrepancies with Invisalign. To limit their expectation, three doctors utilize expansion type appliances prior to beginning Invisalign treatment with minor cross bites to eliminate the predictability challenges. Three practitioners look to cross elastics as a fail-safe, adding them later in treatment when reality is not following the digital simulation. One outlier existed, never using an auxiliary appliance. His comfort level being higher, he manipulates the software to deliver the same results he would obtain with traditional fixed appliances.

Table #3. Qualitative Data: Transverse Discrepancy					
	Dr. Nicozisis	Dr. Bowman	Dr. Amy	Dr. Ginsberg	Dr. Husain
Transverse Discrepancy					
<i>Degree of discrepancy</i> <i>Skeletal</i> >3mm dental <3mm dental	-Hyrax -dento-alveolar -dento-alveolar -dento-alveolar -dento-alveolar	-Expand first -Minor ones -Minor or single tooth - <3mm	-single tooth, or couple tooth cross bite (anchorage mesial or distal) -Premolar tipping	-one tooth -7s not in crossbite	-Tipping -edge to edge -single tooth crossbite

Table #3, continued					
<p><i>Overcorrection (mm) / torque (buccal root)</i></p>	<ul style="list-style-type: none"> -labial root torque -less cingulum visible on the 4/5/6/7 at the end of the ClinCheck -labial root torque -visual thing (mm) -somewhere between 5-10 degrees 	<ul style="list-style-type: none"> -buccal root torque -buccal root torque -I do it myself in the ClinCheck -no measurements at this point -intruding those palatal cusps -be rotated 2 or 3 degrees past ideal 	<ul style="list-style-type: none"> -2-3 mm of excess expansion -labial root torque -buccal root torque -2-3mm for overexpansion -eyeballing (root further than crown) 	<ul style="list-style-type: none"> -first create space -use the other teeth as anchorage -no need to over expand 	<ul style="list-style-type: none"> -over exaggerate the correction -tipping the lowers in linguallly and the uppers our labillary -at least 15-20 degrees labial root torque -palatal intrusion -over intrude that palatal cusp -About 20 degrees of torque
<p><i>Attachment design (Align vs customized)</i></p>	<ul style="list-style-type: none"> -beveled gingival attachment 		<ul style="list-style-type: none"> -beveled or optimized -optimized beveled (if not option) 	<ul style="list-style-type: none"> -attachment don't matter (type of) -beveled attachment lingual as well as on the buccal 	<ul style="list-style-type: none"> -horizontal beveled to the gingival (buccal) -beveled to the occlusal (palatal)
<p><i>Auxiliary/ elastics/ braces</i></p>	<ul style="list-style-type: none"> -never used an auxiliary appliance 	<ul style="list-style-type: none"> -quad helix -RPE -surgically assisted RPE -mini screw supported expansion -buttons and cross bite elastics 	<ul style="list-style-type: none"> -cross arch elastic first -elastics during treatment -cross arch elastics -cross arch elastics 	<ul style="list-style-type: none"> -quad helix -Hyrax -Cross elastics (if failing) 	<ul style="list-style-type: none"> -quad helix expander

5.1.4 Vertical Discrepancy

A. Open Bite

Techniques in the treatment of open bite cases were most consistent among those interviewed of all discrepancies. Some say, “Treating anterior open bites with Invisalign is the new Class I crowding.” Multiple experts went as far as to deem Invisalign superior to traditional fixed appliances in the treatment of dental open bites. The techniques used rely heavily upon the ability of the Invisalign appliance to intrude molars, as well as extrude incisors.

ClinCheck manipulation in the form of over correction, just as with extraction and expansion treatment, is heavily relied upon. Prescribed over intrusion of molars is generally not thought of in terms of millimeters. Again, experts rely upon "guesstimating" and refinements to obtain the proper amount of molar intrusion. They “expect some auto rotation and adjust from there in the next series of aligners.” Some did provide estimates that included intrusion of 3mm at the second molar and 2mm at the first molar.

Attachment design and requirement is less of interest to these orthodontists. Due to the broad pushing surface that is the occlusal surface of the tooth, there was no mention of attachment requirement to aid in obtaining molar intrusion. In describing the occlusal surface, “It is broad, maximizing surface area and you are pushing as perpendicular as possible.” As a way to provide increased occlusal contact, virtual bite turbos maybe placed on the posterior occlusal surface or the use of aligner chewies in the

posterior. Another orthodontist interviewed places a beveled attachment on the premolars as added retention for the aligner.

Pure extrusion of anterior teeth can be a challenge with Invisalign. These doctors, therefore, depend on relative extrusion when vertical change of the incisors is desired. Common among those interviewed is the protocol of tooth movement used to obtain extrusion. First teeth are first pushed labially, creating space. Then, as the teeth are retracted, they are simultaneously extruded by the pushing mechanics of the Invisalign appliance. The aligners work by pushing, “so if you attempt to extrude a tooth by pulling down along the long axis, it will not work.” Finally, of utmost importance when trying to extrude a single tooth, is the necessity to create visible space to prevent interferences as the tooth extrudes.

With this technique, it is unclear the amount of pure versus relative extrusion one can obtain. Therefore, when pure extrusion of only a single tooth is desired, one doctor utilizes a different approach. This technique, called the bootstrap, requires space between the aligner and the tooth requiring extrusion. Then elastics are wrapped around the aligner and hooked to buttons placed on the tooth. This forces the tooth into the aligner, extruding it to the desired location.

Through attachment design, the others still look to ClinCheck manipulation, rather than auxiliaries, to tackle the uncertain efficacy in incisor extrusion. Two of the five use the customary gingival beveled attachment to provide a broad pushing surface for extrusion. Another prefers the traditional horizontal rectangular attachment design to provide the greatest amount of grip as obtainable. The last orthodontist, the same who prefers Align's optimized attachments in extraction and expansion cases, utilizes

optimized attachments when available to obtain extrusion. He will go as far as to, “create the movement required to get those attachments.” Evident is the different techniques to tackle the same challenge. Through manipulation of the software, these Invisalign experts are creating different methods to obtain the same end result.

No auxiliary appliances such as braces are generally mentioned as being required in open bite treatment with Invisalign. The efficacy, therefore, is significant in the approach to open bite vertical discrepancies with Invisalign due to molar intrusion, subsequent autorotation, and incisor extrusion.

Table #4. Qualitative Data: Vertical Open Bite					
	Dr. Nicozisis	Dr. Bowman	Dr. Amy	Dr. Ginsberg	Dr. Husain
Vertical Discrepancy: Open Bite					
<u>Incisor Extrusion</u>					
<i>Attachment design (Align vs customized)</i>	-beveled gingival -beveled gingival		-Optimized attachment -optimized attachment -Optimized attachment	-beveled attachment	-horizontal attachments

Table #4, continued					
<i>Overcorrection (mm)/ ClinCheck manipulation</i>	-teeth labially, create space, then extrude with retraction -pushing -pushing -push -push -push	-lack of space -make space first -make the space first -.3mm of visible space -lack of space -eruption socket	-create some space -create some space -extrusion and retraction	-extrude the anterior teeth	-extruding the anterior teeth -4mm overbite (when want 2) -create spacing
<i>Auxiliary/ elastics/ braces</i>		-boot strap -boot strap -boot strap			
<u>Molar Intrusion</u>					
<i>Attachment design (Align vs customized)</i>	-Occlusal surface (no attachment) -Occlusal surface (no attachment) -Occlusal surface (no attachment)		-beveled attachment (on premolars)		

Table #4, continued					
<i>Overcorrection (mm)</i>		<ul style="list-style-type: none"> -buccal root torque -intrude upper posteriors -intrude lower posteriors except for the second molars -increasing the curve of Spee on the lower -I am more observational -Intrude upper second molar by 3mm, the first molar by 2mm, the lower bicuspid and molars by a couple mms 	<ul style="list-style-type: none"> -intrusion of 1-2mm -create a curve of Spee -curve of Spee -not a cookbook -refinements -refinement -refinement -no specific number 	<ul style="list-style-type: none"> -intrude the posterior teeth -intrude the posterior teeth -seat of the pants -intruding sequentially 	<ul style="list-style-type: none"> -intrude the second molars first -VBRs or virtual bite turbos -Guestimate -virtual bite ramps
<i>Auxiliary/ elastics/ braces</i>		<ul style="list-style-type: none"> -aligner chewies 	<ul style="list-style-type: none"> -chewies in the back -chewies in the back 	<ul style="list-style-type: none"> -Overlay -TADs circumferential elastics and some buttons 	

B. Deep Overbite

A common cause of deep overbite malocclusions are due to a deep curve of Spee. It is, therefore, it's correction that is of most importance to the Invisalign practitioner. There is expectation of incisor intrusion and premolar extrusion in leveling the curve of Spee. Most difficult in this method is control of premolar extrusion due to the anatomy.

Massive over correction is built into the software in comparison to that of open bite treatment. This ClinCheck manipulation includes uprighting of the curve of Wilson, extrusion of the bicuspid, and intrusion of lower canine to canine. Over intrusion of lower incisors and over extrusion of premolar is consistently prescribed by all to the point where the ClinCheck demonstrates a 1-2mm anterior open bite. This divergence between the digital image and reality is expected, “just like putting a greater curve in the wire than what actually translates.”

Introduced by Align in the G5 protocol, vertical bite ramps are unanimously applied. They allow disarticulation, preventing unwanted posterior intrusion, as well as providing an intrusive force to the lower incisors. To provide increased pressure for lower incisor intrusion, one doctor recommends anterior chewies.

Similar to other methods, attachment design varied among those interviewed. Included were large horizontal rectangular attachments on the premolars, optimized attachments, and a statement of no preference. The same principal that applies the broad occlusal surface to obtain molar intrusion, no attachments are employed to obtain intrusion of the lower incisors.

Table #5. Qualitative Data: Vertical Deep Bite					
	Dr. Nicozisis	Dr. Bowman	Dr. Amy	Dr. Ginsberg	Dr. Husain
Vertical Discrepancy: Deep bite					
<i>Curve of Spee</i>	-Level curve of Spee -curve of Spee	-reverse curve wire -reverse curve wire	-greater curve in the wire -reverse curve of	-curve of Spee	-massive overcorrected curve on the lower -curve of Spee
<i>Attachment design (Align vs customized)</i>		-bite turbos	-optimized attachments on the premolars -optimized attachment -optimized attachment	-type of attachments is not that important	-big horizontal attachments on the bicuspids -broad surface (of teeth, no attach)

Table #5, continued					
<i>Overcorrection (mm)/ ClinCheck manipulation</i>	-uprighting the curve of Wilson -extrude the bicuspids -intrude the lower 2-2 -upright the curve of Wilson transversely	-2mm anterior open bite in the first series	-G5 protocol overbite to maybe -2 -extrude the premolars -G5 protocol -bite ramps -extrusion on the bicuspids -pushing lower 3-3 down -bite ramps -Posterior expansion -upright your molars -Intrusion of the anterior teeth -added torque	-bite turbo make my own bite turbo (large overjet) -finish to a mild anterior open bite -intruding the anteriors and leveling the posteriors	-bite turbos -VBOs or virtual bite turbos -anterior bite turbos -over extrude bicuspids -over intrude lower incisors to an open bite -overcorrect by 1-2mm -bite ramps
<i>Auxiliary/ elastics/ braces</i>			-chewies in the front		

CHAPTER 6

DISCUSSION

The ultimate specialist orthodontist knows and understands not only all the biology there is to know, but can prescribe the exact input needed to accurately predict the outcome of any scenario. These special orthodontists know the forces that are generated in the materials that apply the stimuli, the characteristics of the materials used, and finally, know the response of the hard and soft tissues in determining the nature of tooth movement (Tuncay, 2017). This study attempted to assess and elucidate the deep layers of such understanding and sophistication by selecting five known expert orthodontists on the treatment of complex problems with Invisalign.

Based on the results from this study, the current state of aligner treatment has not reached this level of sophistication of Tuncay's statement above, just yet. These expert orthodontists' faith in Invisalign attachments, over-correction, and efficacy of virtual mechanics in ClinCheck are strongly influenced by the malocclusion and their previous experience. Some experts seek to push the limits by re-configuring mechanics of the aligner appliance while others still rely upon auxiliaries and braces to improve predictability. Clearly, aligners for certain types of tooth movements, is a predictably performing appliance in everyone's hands. This study revealed experts who work to solve the unpredictable problems with different thought process, do it by changing their habits of thought. Specifically, instead of expecting help from fixed appliances, they modify their approach to problem solving in the planning of treatment stages. They have developed notable sophistication for how to adjust the severity of bends, offsets, insets

and reciprocal forces. They can project into the future and anticipate where the problems will emerge under what circumstances.

Orthodontists have gone through such change of thought and habit when the switch from multi looped wires to NiTi was made. These two approaches moved the teeth differently, and they required different force systems and modules. Long before that, was the switch from round to rectangular wires.

Because clear aligners were such excitingly novel and easy to manage in the clinic, much effort went into the improvements in the system. This level of innovation and advancement has quickly and determinately expanded the application of Invisalign beyond its early days of minor tooth movement. The ability to treat complex cases such as transverse, vertical, and sagittal discrepancies has grown significantly despite the poor efficacy previously mentioned in the literature (Kravtiz, 2009). The improvements to aligner material and a greater understanding of force systems and staging has enabled practitioners to treat these complex cases more predictably, albeit not precisely.

When queried on cases that did not adequately predict the final tooth outcome, unanimous was premolar extraction treatment. The unpredictable element was none other than tipping and anchorage loss. Fixed appliances has seen this movie many times. The expert Invisalign orthodontists could predict the need for multiple mid-course corrections or acknowledge Invisalign's "limitations" and seek the aid of auxiliary appliances. True precision has yet to be mastered: the ability to get through the initial series of aligners without need for refinement. With lack of precision, experience with the Invisalign appliance has trained these practitioners to manage patient expectations in extreme cases.

This study revealed that the drive of the orthodontic intellectual, has focused to: truly comprehend all the active force systems, properties of the material in applying these, and proper staging of orthodontic tooth movement throughout treatment. The lesser known issues of orthodontic treatment with Invisalign is the viscoelastic and cellular responses of periodontal structures and the role of constancy of force application in tooth movement, as well as, the results achieved. The expert Invisalign orthodontists enjoy the challenge of thinking and studying the challenges of tipping and root paralleling in extraction treatment. Some (despite their best wishes) are aware of limitations or aligners and take the practical approach to resort to sectional fixed appliance, while others persevere to push the limits of aligner design and properties by re-constructing the mechanics to improve predictability. As such, one orthodontist will purposely create a severe divergence between the ClinCheck software and reality by over-intruding the molars, adding significant mesial root tip the posterior teeth, and anterior facial crown torque in his attempt to counteract the deleterious effects of space closure. Such mechanics require future evaluation to determine its efficacy. We posit these are the solutions by a small cadre of bright, yet amateur mechanical and structural engineers. It is unfortunate that tools to indubitably study complex force systems in the human body are not yet available.

In turn, all manipulate the ClinCheck software; some push it more than others. And the most commonly practiced manipulation is over-correction. None of the respondents could provide a millimetric amount of overcorrection. Despite continuous improvements and advances built into the Invisalign system, our experts still heavily rely upon their previous experience. Interestingly, the previous experience is comprised of

traditional principles of biomechanics, which fundamentally are derived from fixed appliance systems. As the orthodontist strives to become the ultimate specialist, evident is the need for scientifically generated millimetric precision, rather than experienced prediction in over-correction. But is it possible?

Based on our data we argue “not.” No matter how knowledgeable a person is in mechanics, in the absence of knowing biology and determinants of viscoelastic responses, let alone patient compliance, the knowledge of mechanics does not apply past static systems. In the face of such uncertainty, intuition and art of the expert orthodontist is the best means to craft mechanical systems. Indeed, just as the Invisalign product itself has evolved over the years, so has the clinician in understanding its applications; we call this mix of art and science, expert’s intuition. Consequently, driven by their intuition, orthodontists in this study limit expansion with Invisalign to 3mm or less having modest expectation in the realities of ClinCheck prediction. These low expectations, again, are guided by those same principles born in fixed appliances. Whether fixed or removable, tipping is known to occur with expansion. To counteract, increased buccal root torque in conjunction with intrusion of the palatal cusp is generally required. Regardless of the amount, consistent among all ClinChecks was an increased degree of buccal root torque where the root is beyond the crown. They are all cautious, however, in prescribing the degree of buccal root torque. Years of experience using the Invisalign appliance have taught them the limits of transmission of forces with minimal grip. They know there is no “force or grip booster” for the plastic to create the vectors necessary. Because they also know that treatment progress is not as easy as the computer animation sometimes dictates, they rely on “time” factor. That is constancy of force application. Some

measures may work for a good patient, but not on a non-compliant. There has to be a greater understanding -beyond art- of the biology and mechanical environment for the aligners to produce repeatable, good clinical outcomes.

In order to achieve the desired outcome, regardless of the treatment appliance, the practitioner should dictate the treatment plan. This results in how the aligner treatment proceeds and where the teeth are to be moved. So just as with fixed appliances, anterior open bites can be addressed by either intrusion of posterior teeth, extrusion of anterior teeth, or a combination of both. Even with extrusion of anterior teeth, an advantage of using aligners is the posterior intrusive affect that aligners will have on posterior teeth. Multiple experts went as far as to deem Invisalign superior to traditional fixed appliances in the treatment of dental open bites.

Therefore, analogous to extraction and expansion treatment, ClinCheck manipulation in the form of over correction is heavily relied upon in the treatment of dental open bites. Prescribed over-intrusion of molars is generally not thought of in terms of millimeters. Experts rely upon their instincts and refine the ClinCheck images to obtain the proper amount of molar intrusion in the mouth. They expect some autorotation and adjust from there in the next series of aligners. Such manipulations provide the clinician with prediction based on experience, rather than translation of ClinCheck precision to clinical realities.

One of the difficulties that new Invisalign users face while using the appliance is the inexperience in identifying challenging cases. Deepbites, which can be difficult with aligners, are generally treated by anterior intrusion, or leveling of the curve of Spee. To facilitate this movement, these expert Invisalign practitioners utilize premolars for

anchorage while an active intrusive force is placed on the incisors. Over intrusion of lower incisors and over extrusion of premolar is consistently prescribed by all to the point where the ClinCheck demonstrates an anterior open bite. This divergence between the digital image and reality is expected, just like putting a greater curve in the wire than what actually translates. Incisor intrusion depicted in ClinCheck images can be difficult or take a protracted amount of time with aligners.

The available literature for aligner treatment continues to grow over the years. However, while this collection of data are informative, it can become dated quickly. Training clinicians, therefore, to use the Invisalign appliance is still largely based on anecdotal evidence. In an effort to develop a more robust knowledge base to build clinician skills, this study was designed to assess how expert clinicians address the divergence between ClinCheck simulation and actual tooth movements with Invisalign.

So as innovation continues to advance the aligner appliance, ever important is the biomechanics of tooth movement born in fixed appliances. No matter the malocclusion, orthodontic principles must govern and dictate the movements. Fundamental to the success of these movements is over engineering of the ClinCheck software. Over-correction provides the practitioners the tools to generate forces within the material in order to apply the appropriate stimuli not only at the beginning of treatment, but step-by-step, aligner-by-aligner. In traditional orthodontics, adjustments are made at each patient visit. In the world of digital treatment, the anticipated end result and how to get there has to be thoroughly visualized from day one. ClinCheck software is only a virtual treatment-planning tool used to communicate a treatment plan. It is the practitioners' knowledge that is critical in evaluating the tooth positions and movements required to achieve the

expected outcome. Clinicians will always have different experiences and different plans. ClinCheck software serves as the means by which the clinician can dictate their force or biologically driven modifications.

In this study, methods of ClinCheck manipulation and prevention were evaluated. No study, however, is without its limitations. At first glance, sample size would appear as the obvious limitation. This is not the case for qualitative research. In qualitative research, a small sample size is critical. A small sample size allows the researchers to carefully analyze each result and interpret the interviews. Due to the exploratory nature of this study, a small sample had to be utilized. Open-ended questions, while advantageous for qualitative research, make analysis more operator-sensitive. Open-ended questions provide a great variety in responses and information provided. When such questions are used, it can be difficult to observe trends in answers provided. Qualitative research is still a relatively new approach in health sciences, and investigators are still learning how to best use this data. In this study we had focused on commonalities rather than collecting clinical gimmicks.

These results point towards exciting areas of future research. There is an apparent need for technology to incorporate orthodontic smartness if the ClinCheck software desires the highest degree of predictability and precision. The Invisalign aligner must improve its protocols and tools for not only treatment planning, but aligner mechanics. Some questions include: how many degrees of root convergence into an extraction site or how many degrees of buccal root torque is adequate to obtain the desired transverse bodily movement? These protocols could eliminate the guess-based overcorrection. Moreover, protocols based on the malocclusion may be expected to enhance the patient

experience, but also the clinician's as well. Eventually, patient biology, the genes and their environmental inputs, will be required if digital orthodontic treatment planning and aligner therapy are ever to become the true state-of-the-art treatment for the ultimate specialist orthodontist.

CHAPTER 7

CONCLUSIONS

The focus of this research was to address the corrective measures and divergence between virtual simulation and the clinical reality with Invisalign. The data in this report consisted of extraction, vertical, and transverse discrepancy treatments with Invisalign. Qualitative data was fractured and conceptualized to produce techniques and preventative measures required in order to achieve the desired outcome. There is still a plethora of uncertainty and limitations to appliance manipulation. Meanwhile, based on our data the following conclusions may be drawn:

1. Extraction Treatment
 - a. Overcorrection in the form of virtual gable bends into the extraction site in order to counteract the desire for teeth to tip.
 - b. Despite many attempts at prevention, occasional requirement of fixed sectional braces to obtain root parallelism.
2. Transverse Discrepancies
 - a. All orthodontists in this study limit expansion with Invisalign to 3mm.
 - b. Auxiliary appliances such as a quad helix, hyrax, or cross elastics are commonly required for more severe transverse discrepancies with Invisalign.
 - c. Constricted arches receive expansion with over correction by translation, buccal root torque where the root is beyond the crown, and intrusive movements.

3. Vertical Discrepancies

a. Anterior Openbite:

- The efficacy is significant in the approach to open bite vertical discrepancies with Invisalign due to molar intrusion, subsequent autorotation, and incisor extrusion.
- Prescribed over intrusion of molars is generally not thought of in terms of millimeters; instead, upon personal estimation and refinements to obtain the proper amount of molar intrusion.
- These doctors depend on relative extrusion when vertical change of the incisors is desired.

b. Deep Overbite

- Leveling the curve of Spee by over-intrusion of lower incisors and over-extrusion of premolars is consistently prescribed by all to the point where the ClinCheck demonstrates a 1-2mm anterior open bite.

4. The expert orthodontist's faith in Invisalign attachments, over-correction, and efficacy of virtual mechanics in ClinCheck are influenced by the malocclusion and their previous experience.
5. Some experts seek to push the limits by re-configuring mechanics of the aligner appliance while others rely upon auxiliaries and braces to improve predictability.
6. Hypothesis-driven experimental studies may now be designed.

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APPENDICES

APPENDIX A

INVITATION TO PARTICIPATE IN STUDY

January 4, 2017

Dr. Name Surname
House No., Street
City, State zip

RE: Master Thesis Project

Dear Dr. Surname,

I am currently a first year resident in the Orthodontic Program at Temple University. As part of my post-graduate training, I am conducting a research project to investigate how the master clinicians of Invisalign manipulate the appliance from ClinCheck to final result. Specifically, I am assessing how you manage extraction, vertical, and transverse plane difficulties.

This method of investigation is known as Qualitative Research. Data are collected by an interview. Accordingly, I plan to interview a number of orthodontists with similar profiles as yours in the Mid-Atlantic and Northeast region. During these interviews, I would like you to respond to inquiries of solutions and preventive measures needed to address the divergence between virtual simulation and the clinical reality with Invisalign.

If you could allow yourself to be interviewed, please respond affirmatively to this letter via telephone or email. I would consider it a great favor if you would.

Thank you for your time and consideration to read this note.

With kindest regards,

Jordan Cogan, DMD

Cell: (267) 671-8727
Email: jordancogan@gmail.com

APPENDIX B

DR. JONATHAN NICOZISIS TRANSCRIBED INTERVIEW

Are there any cases you don't feel comfortable treating with Invisalign?

Comfort and confidence is something that I am not lacking at this point in my acumen with Invisalign. I think for the question becomes down to what do I think will be efficient or predictable, I suppose, is the word. And by predictable, I mean more refinement. In its definition, knowing which types of cases are going to give us challenges. Defining what those challenges will be and how we are going to circumvent them and deal with those challenges. So right now the big thing I am working on, the obvious, making the four bicuspid extraction case predictable. Meaning that I can get through the initial series of aligners and everything is fitting well. And right now I manage my patient's expectations and mine for those types of cases that I will more than likely be taking multiple scans or impressions and dealing with things accordingly. There are a lot of factors involved. The obvious: the age of the patient. Teenage four bicuspid extraction is much more amenable than someone who is 50 years old. Periodontium and the response of it is just very much different. You've got the skeletal pattern. Deep overbite pattern versus high angle pattern. Where are the teeth to begin with? Are the cuspids just blocked out and you remove the 4's and you just drop them in simply with minimal second order movement or is it 90% second order movement where we have to worry about moving the teeth bodily. So to answer your question directly, which cases am I not comfortable with or which are not predictable is four bicuspid extraction. Do I move the teeth en masse or do I doing it in staging where I move the cuspids back a third

of the way first, then go back to the anterior? So there are staging issues. That is something I am still working on. But I am very confident that in five-six years from now it will be checked off the list of cases once thought of as impossible. Just like anterior open bites etc. I treat teenagers, mixed dentition, early treatment now with Invisalign. I treat surgical cases routinely now with Invisalign. Impacted cuspids I am treating with Invisalign using auxiliaries like TPAs with lever arms, incorporated etc. So that is really where I am at this point.

When you talk about extractions, four bicuspid extractions, commonly the problem with Invisalign is tipping of the teeth into the extraction space. So how do you handle that or prevent that from occurring?

Well, so the best way that I try to deal with it is in my ClinCheck treatment plan, I think of fixed appliances. So for me, I reverse back to my days at the Tweed course. And so how do I prevent it? There is obviously gable bends involved and to the point of the extraction site. There is making sure that I got attachment surfaces pushing on the clinical crown to elicit forces or making the center of rotation inside the clinical crowns that will elicit forces at the center of resistance of the teeth someone where up apical into the root to get the roots to move together. And the last thing it took me many years to figure out is that I have to manage the vertical and so that with your tweed closing loop arch wire you gable bend in the extraction site number 1, you torque the anterior teeth number 2, and you that last thing you do and which I took for granted and learned by bitter experience is that you take your hollow chop plier and you wipe a curve in your wire so that you got this crazy looking wire. You don't expect that to be fully expressed when you insert it

and activate the force system. And so in my ClinCheck system, how do I manage that? I intrude the posterior teeth so I end up with 3-4mm of freeway space from the occlusal surface of the U7 to the L7. And maybe 3mm of freeway space from the U first molar to the lower first molar. And then 2mm of freeway space from the 5s. How do I manage the teeth from not tracking? You ultimately have to think about what you take for granted with fixed appliances. And distill that down and build it back up component by component into your ClinCheck.

What we have learned, or what Dr. Tuncay employs, is to prevent a molar from tipping into an extraction space, he will use a large rectangular, prominent attachment. Is there a specific attachment you employ in order to prevent this?

Yes. I have done that and it works to a certain degree. But obviously we are always striving to try and make things better. And so for me I have evolved to thinking about what I do for second order. Really what you're talking about is controlling the second order movement of the molar. So for me, how do we control the second order movement of the cuspid into the extraction space? Well we have got the twin attachment on the G4 series on that to elicit a center of rotation in the clinical crown to affect the distal root tip. So what are those attachments like? They are twin attachments, and their orientation is vertical. Why are they vertical? Because the cuspids are taller than they are wider. So they are vertically oriented so that you have a longer lever arm. So with that knowledge and concept how can we translate that action to molars? All I have done is taken my G4 twin attachment on the cuspid and changed the orientation 90 degrees and I call it my molar ying yang attachment, which I just had a publication on. It was in the

Progressive Orthodontist so you have that as a reference. And so molars are wider mesiodistally than they are tall, occlusal gingivally. So all I have done is change that orientation of the attachment 90 degrees to fit the molar. Now, instead of my broad rectangular attachment, I've got a twin attachment on the molar to mimic the second order attachment on the anterior teeth. So it's not just the attachment, but it's also the movement. You can see in that article, my failure was control the vertical. So initially, as I would move those teeth, bringing the molar forward all on the same plane and what I saw after 11 months was how I would get that bowing effect. So the key to prevent molars from dumping, whether you use the ying yang, or the molar rectangular attachment, is you must secondly apply mesial root tip and then, as importantly, intrude those teeth to mimic you putting a curve in your Tweed closing loop arch wire. And so you end up with freeway space. And that's how I manage my molars from dumping and I have found that those key three things, the ying yang, the mesial root tip and the intrusion to mimic curve in closing loop arch and reverse curve in the upper, they end up with freeway space off the occlusal plane, much like Tweed tip back bends, is the key to preventing the molars from dumping in extraction cases.

So you have that freeway space, do you see that clinically and if you so, does it settle out?

Again, I always go back to my friend Charles Tweed. People get their pants in a pucker when they see things on ClinCheck that looks strange. And really ClinCheck is not teeth moving. ClinCheck is designing forces being imparted on teeth via plastic. And so you must think about what you are seeing on ClinCheck and how that translates to

forces. And so to answer your question directly, no you don't see that freeway space clinically, and if you do, Tweed had his tip back bends and he intruded those molars for anchorage, like tent stakes. Then he had a phase called the recapture phase that took well over a year for those teeth to drift vertically towards the occlusal plane and establish contact again. If I do end up with posterior openness, it will settle. It happened back in the 1900s for Tweed and it can happen in the 2000s for Nicozisis with plastic. That is not my concern or that is not a concern of mine today.

In the beginning, you mentioned the vertical, with patients having deep versus open bites. In addressing the vertical, you mentioned having success in treating anterior open bites with Invisalign. Is there anything specific that you do in order to help guide your ClinCheck in treating those cases?

Treating anterior open bites with Invisalign is the new Class I crowding. It is the new black in orthodontics. I mimic, the MEAW appliance, multiple loop edge arch wire. Developed by Dr. Kim outside of Boston. It is a series of boot lops with progressive tip back bends. And in fixed appliances you basically have a crazy curve on top and reverse curve on the bottom which seem counter intuitive for an anterior open bite, but then you use anterior vertical elastics to basically transfer all the intrusive force to the posterior dentition. With the MEAW appliance, you get not just intrusion but you also get uprighting of each tooth along the occlusal plane. And you basically alter their position along the occlusal plane. That combined with some auto-rotation of the mandible forward helps close down the anterior open bite. The difference with plastic is I never use vertical elastics and the beauty of plastic is when you put in the mouth, it is tweaked, or the force

system is such that if they don't wear elastics like with fixed appliances, it isn't going to get worse. So a fair statement to say, a true statement to say is that no anterior open bite has gotten worse when treated with Invisalign ever. And you can't say that with braces. So I mimic my MEAW appliance and segmentalize the movement. Now I don't segmentalize each tooth movement. I move the teeth simultaneously because I know some doctors or faculty members advocate intruding the 7s first, then the 6s, and 5s segmentally. That does work. I am not here saying it doesn't work. I think it's working too long. It takes longer. And again in my mind, it is about mimicking the action of fixed appliances and with fixed appliances, when I use the MEAW wire, it doesn't know to act on the 7s first, then 6s and 5s. It does it all at the same time. So I will intrude the teeth simultaneously. I also don't need an attachment to intrude because I am pushing on the occlusal surface. Lets discuss the occlusal surface. It is broad, maximizing surface area. One of my big mantras is surface area. So maximizing surface area, pushing on the occlusal surface. Pushing as perpendicular as possible. So I don't need an attachment for that, and I am pushing as far behind the center of resistance as possible so I have better directional control. Meaning I am pushing from the occlusal surface through the alleged center of resistance, so I satisfy all three of my key components.

So in order to intrude, do you first find it necessary to create the space?

Interproximally the space? If it's a single tooth, molar or anterior, yes. If it is a MEAW anterior open bite, no. I have not needed to do that to intrude those teeth.

Is it more molar intrusion versus incisor extrusion when handling anterior open bites?

Then it comes down to your differential diagnosis. Which teeth are the offending teeth that are off the occlusal plane? I have some cases where its both upper and lower 3-3 that are off the occlusal plane. So I have a reverse smile line and a reverse smile arc on the lower, if there was such a thing because the tongue is pushing forward. I've had other cases where the lower teeth are ideal and the lower anterior teeth are on the occlusal plane. It's the upper anterior teeth that are off the occlusal plane with the reverse smile line. So in designing the ClinCheck in a case like that, I will not extrude the lower anterior teeth. I will only intrude the posterior teeth, yet on the upper I will intrude both the posterior and extrude the anterior teeth. I have case after case to show an improvement of the smile line and correction of the anterior open bite.

Extrusion of anterior teeth, especially incisors has been proven to be a pretty difficult movement with Invisalign. So again, is there anything specifically that allows you to achieve that kind of movement?

Yes. Where I made my splash in 2007, where I may my first summit presentation, my presentation was titled extrusion with aligners only. No auxiliaries. And basically back then, I told Invisalign they were doing their extrusion incorrectly. By that, I mean, the attachments [were] beveled incisally, which was wrong and they were not designing extrusion properly. Extrusion is a two part process. It is a beveled gingival attachment and it is a proper movement protocol. You bring the teeth out labially, create space, then you extrude with simultaneous retraction, so that you're always pushing on the tooth

because your appliance system of choice, is a pushing piece of plastic. Aligners cannot pull. They can only push. So if you attempt to extrude a tooth, by pulling down and out the long axis of the tooth, it will not work because you can not pull. Instead you must push it out labially, creating space. After space creation, you then reverse your direction of force to push to extrude with simultaneous retraction. When I talked about that at the summit, it caused a lot of people to get upset because I was not towing the company line and after 2.5 years, when John Morton came on board in 2009, I was validated when he did his bench top engineering testing. Indeed, he said and proved that the beveled gingival is the better orientation because it allows for tolerance. So if there is any slippage, it will continue to push the tooth in right direction. If you bevel it incisally, if there is slippage with that little ledge, you are screwed because the tooth will not continue to track. But it's not just the bevel; it's the proper design of tooth movement as you saw on the two coaching cases I showed you. To answer your question directly, what can I do to make anterior extrusion predictable, is to follow my protocol that is from my first publication in 2006, from Dr. Tuncay's publication which I is called Clinical Tips and Techniques from the summer of 2006.

Vertical deep overbites are still proving to be a little bit of a challenge with Invisalign. How do you handle these clinical situations?

That was from a white paper that I published for Invisalign that I think was in 2010 or 2011. But like anything, it comes down to your differential diagnosis. Age of the patient. Teens are much more predictable than adults. It comes down to the skeletal pattern. With the teen they are growing. You have facial growth in your favor to open up

bites vertically. With adults, if they are flat mandibular plane angle, you are kind of screwed. And I remember Dr. Christen Terry Albright, she did her masters thesis on leveling the curve of Spee in brachycephalic patterns and whether or not it returns afterwards. She showed that if your brachycephalic, the return of the curve of Spee will return to a certain degree. But again you're asking what factors do I employ? Well after I look at all that differential diagnostics, I never forget to look at uprighting the curve of Wilson. While I will extrude the bicuspids, and intrude the lower 2-2, I then go back and upright the curve of Wilson transversely. It is a huge help in opening a bite in somebody that is either non-growing and/or has a deep bite pattern.

Will you incorporate any overcorrection? And, how much, if so?

Oh sure. I also hate the term overcorrection because it notes that I can have some magical value that I can dial into my ClinCheck. It's not overcorrection in my mind. It's mimicking the action of fixed appliances. How much curve do you wipe into your reverse curve of Spee? You don't know. So when it comes back in 6-8 weeks and the lower arch is still concave, you don't say, damn you fixed appliances, you didn't work. You take your wire out and you recharge your force system and rewipe your curve and you shove it back in. When they come in a few weeks later and that does not work, you step down 2-2. You now have the crazy reverse curve wire that looks like an escalator How much step bend do you put in? How much torque do you put in a wire? Unless you're a true Tweed practitioner, and measure your exact torque, [you don't know]. There is no magical number in my view. But I will tell you this, where as in a lot of my previous publications where I used to advocate extruding the 4s and 5s 2mm and intruding the L 3-3 3mm to

get this crazy looking occlusion, that was with the old material. The stiff EX 30. I will say to you now, with smart track and scanning, I am dialing back a lot of those quote unquote measurements because it's a better performing plastic. I don't have a right answer because I am still tinkering with it myself. What I used to do 5-6 years ago routinely was working out perfectly. Now it's expressing because it's a better plastic.

So you would say you now need less overcorrection because you are actually getting more of the movement?

Yes and with scanning, without a doubt.

Finally, the last thing people have difficulty in correcting with Invisalign is the transverse. So posterior crossbite etc. Do you commonly use Invisalign to address the transverse? Or will you use auxiliary appliances as well?

I use Invisalign all the time. I have never used an auxiliary appliance to address a transverse. If it is a true skeletal discrepancy, then sure, I will do the skeletal correction with a Hyrax. But if it is an adult and I have dento-alveolar teeth that are tipped in. If it's a dento-alveolar crossbite, where upper teeth are pushed in and lower teeth are pushed out, plastic all day long without elastics. I can show you a 48-year-old female unilateral posterior crossbite, dento-alveolar, it was tipped in on the upper and in the lower it was bowed out, and I used proper and Invisalign and I over expanded. Now it's not over expansion. Again, it's mimicking the action of fixed appliances. What would you do if it were fixed appliances? You would take your hollow chop plier in the anterior 2-2 and you would bend it so the upper right side, that was the crossbite side, would go all the

way straight out. Then you would take your tweed plier and you're going to add in labial root torque. Why is that? Because as I expand that out, the tendency is for the buccal cusp to flare out and the palatal cusp to plunge down. So I have to compensate for that. So with my plastic, I am pushing from the lingual out to the labial. From the occlusal view on my ClinCheck, I want to make sure there is less cingulum visible on the 4/5/6/7 at the end of the ClinCheck than the beginning. If I see more of the cingulum, I know I am flaring the buccal cusp and plunging the palatal cusps. If I know I am pushing from the lingual out towards the labial, what's the tendency, again, for the buccal cusps to flare out. The broad surface of the beveled gingival attachment helps keep that tooth locked into the aligner so that you can affect the labial root torque.

Is there a certain amount that you incorporate into that root torque?

It's more of a visual thing. I guess what I am still trying to wrap my head around, is what is that magical amount, Now with the tooth movement table, you can see how much it is. So if I had to quantify it, its probably somewhere between 5-10 degrees. Now with the tooth movement software, you can actually see the quantified amount of movement and so what I used to lecture about and publish about I am kind of dialing it back, because it is a little bit extra. Where I used to say 10-15 degrees, I am now saying more like 5-10.

Do you experience better results in the premolar region that maybe in the molar region in terms of expansion?

Logic would have you say that if the molars are not in crossbite and its just the bicuspid, you're going to have the molars as a nice anchor to get your bicuspid out of crossbite. Likewise if the second molar is not in crossbite, but the 4/5/6 are, I still have huge success. But what you're really getting at is, lets say 4/5/6/7 are in crossbite, how much success are you going to have. I think you better look at your differential diagnosis. See if it is a skeletal issue. Moving teeth with plastic is exactly the same as moving teeth with braces. And so if you can do it with braces, you can do it with plastic. If it is a skeletal issue, it has to be dealt with by any skeletal means you are comfortable with.

Finally, the last topic, do you ever find the need to constrict the arches? And do you have any issue encountering that constriction?

Sure. The constriction is in the front. Let's say you over expanded. What is going to happen to the front? If you over expand a wire, and what is going to happen to the anterior teeth? They are going to dump in. Who would have knew it? Same thing happened with plastic. It is one of those things you take for granted with fixed appliances. Yet in ClinCheck you don't think about. So when I am over expanding the top, I am adding lingual root torque U 2-2. So like wise, if I am constricting an arch form, what is going to happen to the anterior teeth? They are going to flare a little bit. So now I might have to counter with a little bit of crown tip. A force is a force. A couple things Dr. Tuncay mentioned to me in my residency that still ring true. Number one. Teeth are stupid. They don't know where the force comes from. It could be a child's thumb, bracket and wire, or piece of plastic. And Andrew's six keys of occlusion, key number 3, about torque, more specifically the wagon wheel illustration. He said that was the most

important figure I would ever look at in residency and it is so true. Those two things. It's all about translating the actions we take for granted with fixed appliances everyday and relating it to ClinCheck. The challenge is, the problem is, we as orthodontists, when we look at fixed appliances, our mind is like a Pentium seven chip. There are so many computations that are occurring simultaneously that we don't even think about that we take for granted. Putting a bracket on a tooth and these interactions that we take for granted everyday. Yet when we look at cartoon-odontics, and these static images in the ClinCheck, our mind goes back to the days of the Commodore 64. That's when we used to save data on a cassette tape. My point is when we look at these static images of the ClinCheck, we disregard the basic things about tooth movement and forces on teeth that we take for granted everyday. And so it's a challenge to distill it down to its basics and build it back up into the ClinCheck. Those with the silly mindset such that say, "How come I have to think about this?" "How come Invisalign can't just do this automatically?" I say to them, be careful what you ask for. Because then every general dentist could treat every complex malocclusion. Or instead, they could open up right next to Starbucks in the mall. So be careful what you ask for.

APPENDIX C

DR. JAY BOWMAN TRANSCRIBED INTERVIEW

On a scale of 1-10 or however you want to grade it, how comfortable do you feel treating cases with Invisalign?

I think I am probably a 7.5. I do about 100 cases. I am an elite provider. Whatever that means. So about a 100 cases per year. I started out with Invisalign when it came out in 1999. I started out slowly and still have done more Invisalign than anyone in our area. I like Invisalign and I like the option for patients. But I also realize there are a lot of limitations to it. So I have always looked for ways to get around those limitations and to make it more predictable and applicable for more cases. So I am comfortable with case selection for the most part. There are still some predictability problems that we are still trying to address. But it isn't always compliance. So as far as expanding that beyond where we are right now, I would have a hard time doing that. I just think that in those tougher situations, you could do part of your treatment with Invisalign. But there is still not, to what I see, a replacement for braces for those types of cases.

When you speak about difficulty with Invisalign or predictability, which kind of cases are you referring to?

Anything that is in an extreme. So severely crowded situations. Often times I am not that comfortable with extraction cases. Severe Class III or Class IIs. Severe open bites. Surgical cases. Those are the things that there are orthodontists that are using Invisalign for. But they are using a lot of adjuncts with them. I just find that you are

almost kind of handcuffing yourself in some instances to try to make this work for some cases when it may be better for you and the patient to say that lets just do this with braces.

You mentioned extraction cases. Have you ever treated any extraction cases with Invisalign?

Yes I have. And I have patients in treatment with extractions in Invisalign. But I find that there are always some compromise that you are trying to overcome and it generally has to do with tipping teeth and creating some iatrogenic open bite tendencies. Trying to get root paralleling is tough despite what the claims are made for attachments. I am often adding other things in whether it be buttons and elastics, mini screws, or in some instances, sectional braces just in order to get the results that I was looking for.

Are you building anything into your ClinCheck, using specific attachments or elastics to prevent the tipping that you experience?

Yes, probably more recently. More use of anchorage from mini screws to maintain molar position, holding them back while trying to retract against that anchor system with Invisalign. It's still tricky to try and get that all hooked up to work. I am not entirely satisfied with all that because again, you are sectioning the trays to try and get the space closure while trying to maintain the molar position. It's not always ideal.

With extraction cases, it seems like you are referring to four bicuspid extraction cases. Are there any other extraction patterns you may be more willing to do?

Well certainly lower incisor extraction cases work out pretty well. If I am doing a situation when I need to protract a molar, I may be apt to consider a mini screw and then attempt to do that. But what I think you're seeing is 4 bicuspid extraction cases. Whether it's a combination of first or seconds would be somewhat problematic.

With four bicuspid extractions for extreme crowding versus bimaxillary protrusion, would you be more comfortable in a more crowded case versus a bimaxillary case? Or do you experience the same difficulty with tipping?

It's probably the same for both. You are stressing that molar position and since you are squeezing during space closure, you are causing that molar to want to tip forward. It is the control of that molar tipping and intrusion is the problem. So I don't think it really differentiates between those two. I would go back to maybe a bimaxillary protrusive case where you have severe spacing. You would run into similar problems trying to get space closure. It's not quite as bad as [a crowded] extraction case but there are still the same concerns because again, you are using the molars as anchorage. You don't have as much control despite attachments.

Will you use a specific attachment if you are trying to prevent that?

I would probably put some sort of rectangular attachment to help prevent it. Whether that be a vertical, but there is not a lot of space to get a good vertical attachment. So, I guess, we attempt to do that but I also, now, have used more mini screws pulling with rubber bands against either a transpalatal arch supported by mini screws and rubber bands to that. Attachment on the molar meaning a molar tube. Or going to a mini screw

that may be between the upper first molar and second bicuspid or second molar on the buccal and using a class one mechanism of elastics to try and control that.

You rely more on the auxiliary of the TAD rather than rely on Invisalign itself?

Right. It's supporting it, and even with that, in some situations, the molar still tips because you are asking the plastic still to be closing that space by squeezing the teeth together. You are producing more force out of the rubber bands but it's still that balancing act. Trying to control that molar position.

When it comes to the transverse dimension, do you typically use Invisalign for transverse changes?

Again, if we are looking at an adolescent, I probably would have done some expansion preliminarily. I have had patients where I've had a quad helix at the first molars, expanded the upper and as long as it's not an extreme bilateral crossbite. As I expand the upper, sometimes I'll keep the quad helix in place as I start the Invisalign, just to maintain it. Or you could go to a transpalatal arch, but I just keep the quad in there. In more severe situations or older patients, I think you're going to have to make a decision whether you are going to address the expansion with an RPE, surgically assisted RPE, mini screw supported expansion, or make an agreement that we aren't going to address the crossbite. In some adult situations you look at the occlusion and say let's not fix that as long as it's apart of informed consent [and] as long as the patient understands what are the risks [and] what are the benefits. Sometimes the cure is worse than the problem itself.

Will you ever utilize the Invisalign appliance itself to resolve a posterior crossbite?

Yes, minor ones, but I would add in buttons and cross bite elastics with that. I would certainly ask in the ClinCheck to expand the upper jaw in compared to the lower. But I am not expecting that to correct more than a minor or single tooth posterior crossbite.

Would you experience more tipping with the Invisalign appliance [in regards to expansion]?

I do not know the answer to that, but I would have suspicion that would be true. The advantages of Invisalign is that you could ask for more buccal root torque. However, if you are asking for more than 3mm, I am not sure you are getting it. It's just dental tipping. I am not sure you are getting any type of sutural expansion with Invisalign. It's a slow type of expansion and limited in its scope.

When you do ask for buccal torque, when that is something you desire, are you going to use a certain attachment or a certain amount of overcorrection?

I am always asking for overcorrection. This is a quote you can use by Lysle Johnston when meeting with Begg. Begg was showing him notebooks of cases he treated. Lyle asked him questions, like you are asking me, and his question was, "Is there anyone message that you would give to Orthodontists?" His answer was "Yes, over treat, over treat, over treat." That is something that has been a limitation of Invisalign. Their corporate concept has been that this thing does it and you don't need overcorrection. I have found that is not correct. I don't believe the system can fix a lot of things without

overcorrection. But in terms of buccal root torque in the posterior, which I am a big advocate for and it is ignored a lot, I do it myself in the ClinCheck with the tools. I can ask a technician to do that, but I am not sure they get it. I am not sure it gets put into the trays. I do not have any measurements at this point, but I think it would be valuable to find out. I see clinically that the bites fit together better because the bite is not propped open by the palatal cusps of the upper. I want the palatal cusps flat as described in several papers and the ABO index to get those palatal cups flat. I think the advantage to ClinCheck is you have the ability to ask for that and have the occlusion helping you. You have a force that is helping to translate what you asked to put into the plastic into the teeth. You don't have that any place else. You have it for intrusive forces and that's what you are in fact doing with that. You are intruding those palatal cusps and that's what is giving you your torque.

When you speak about overcorrection, do you have a certain amount that you prescribe or do you look and eyeball it?

I do. I ask for specifics when I do this. For example, for rotations, I will typically ask, depending how rotated the tooth is, I will ask for the tooth to be rotated 2 degrees past ideal to the mesial. Or three degrees past ideal to the mesial. It's interesting because often times the set ups come back and all they have done is put the tooth at ideal. I then have to go in and tweak it further or I tell them to. Because I just don't believe that for problematic teeth like upper laterals, you get it corrected unless you overcorrect it by asking for overcorrection. You have the play in the plastic and error in manufacturing, error in impression or scan in the digital world. There is always an error you are trying to

resolve. I am going to quote Roy Satch David, “Finishing is nothing more than correcting all the errors that have cropped up throughout the entire process.” You have made an error in diagnosis, treatment planning and materials. It’s the same with braces. You have the play between the wire and the bracket [and] bracket position. You have all these creep up throughout treatment. To get things done, you need to eliminate all those errors. It’s sad to see many cases presented by lecturers in forums and you look at them, and they are said to be finished. I look at them and just can’t imagine that. I have another quote from a colleague of mine in the Angle Society. Mike Vermette said, “Anytime you think you’re finished, look again.” Because we are perfectionists, we are never done. So I would say to you that without overcorrection I don’t think I could get to correction.

You mentioned finishing which is known to be one of the more difficult things with Invisalign. Also proven to be difficult are extrusion and rotation. Is there anything specifically you do with the ClinCheck or even auxiliaries that help you achieve those movements?

The first thing that I did was with Orhan Tuncay’s assistance is that we came up with the idea was having patients chew on something. It started out as cotton rolls and turned into my concept of aligner chewies to try and get the aligners to seat better. I come from the world of tooth positioners because one of my instructors was Pete Kesling and his father was Harold Kesling who was the inventor of the tooth positioner which was the basis for Invisalign. Invisalign makes perfect sense because it’s a series of retainers to move teeth. Its just less labor intensive because you have the lab part of it done through virtual reality. Using a tooth positioner is an outstanding appliance for finishing. If we

could translate a lot of those concepts into Invisalign for finishing including telling the set up to ask for that overcorrection. But then you start to analyze why things are not happening. There has been plenty of studies done telling us the lack of predictability and low percentage of tooth movements that as you said, have to do with extrusion and rotations, especially upper laterals and canines. So why aren't they moving? Why aren't they going the way we want them to? A lot has to do with a lack of space. In the cartoon you did online, you rotated that tooth and you over rotated it. But the tooth does not do that in reality. Why? Well there is no room for it to. It is caught in the contact points. Unless you can gain space in order to allow the tooth to move you couldn't expect the plastic to be able to get it to move, whatever the attachment maybe. The misdiagnosis that I often see is that there is not enough space. The knee jerk reaction is initially lets grind up the teeth. I say no, why don't we make space first. Everybody is in a hurry to move the tooth to get a labiolingual discrepancy resolved or rotation. Instead lets make the space first. I hear a lot of Invisalign folks talk about opening up visible space before you move the tooth. Everybody has a different technique for it. Randy Kunik will move an individual tooth using two other teeth. He is very specific in the sequence of events that he does. I ask the technician if I have crowded positions or rotations, please provide me about .3mm of visible space prior to movement. And then my next step is to either do IPR if I want to do IPR, but not until I have the visible space and then do the tooth movement. Add in my labiolingual and or the rotation. You can then use your attachments. Up until that point, you are going in the wrong order. Putting big attachments on and expecting this tooth to move is not going to happen. Same thing with extrusion. Most often if somebody sees a problem in a case that is not tracking, it's a lack

of space. If you are trying to extrude say a lateral incisor, you are trying to bring a tooth down between tooth teeth with more surface area. Second of all, the lateral has very little contact with the plastic so attachments will always be helpful, but it still is not going to move if there is not enough space to get the tooth to come down between these two teeth. And those two teeth diverge in size at the incisal edge. You look at this little tiny tooth that is trying to come down through a contact point that if you simply measured the width of the lateral and the space available in the ClinCheck its impossible. People still just don't see that. So if you create the space a put the big attachment on the tooth and it doesn't move, then you still have a problem to solve and that's when I started to add in rubber bands with a button on either one side with notches on one side or two buttons with rubber bands across and over the aligners. We call this a boot strap. Like boot straps on real cowboy boots, the intent is we are grabbing the boot and pulling them on. That is what we are attempting to do with the boot strap elastics. To improve the predictability of the extrusion of that specific tooth. It is also intruding the adjacent teeth so if you measure the effect, part is the intrusion of the canine and central, with the lateral extruding into the socket that has been provided. So to take that a step further. In a class II div II situation, where the lateral is tipped forward, typically crowded and rotated, and you would like some intrusion of centrals, and/or extrusion of laterals, and some other factors of torque and labiolingual discrepancies, I am not going to wait around. I am going to create the space but then I am going to ask the technician to open the space for me for the tooth to be extruded. This means that I am going to create an eruption socket for that final position of the tooth and I am going to ask for that at a particular stage. Lets say that there isn't severe crowding and I want to extrude a lateral, at stage one I tell the

technician, I want this tooth in its final position. In other words, please extrude the lateral 2mm or a 1/4mm past the incisal edge of the central and I want you to move it a 1/4mm labially and I want you to rotate it say 2 degrees to the mesial. Then you are going to extend the gingival margin on facial and lingual of the lateral, because Invisalign wont allow you to put precision cuts there. Or I use my clear correction pliers and I have the hole punch, and Ill do it myself. Often times if I ask Invisalign to extend the gingival margin, which is in effect ending up to produce this hole cut, they wont do it. They forget. So I end up doing it myself. I put the two buttons on in the gingival margin and give them a rubber band and I immediately begin the extrusion process. So it's going to look like the aligner is not tracking from the get go. There is a big gap there or a space for the tooth to fall into. I can't guarantee that is going to work every time. If you start to see some binding, like it's not working, it's ok to cut this plastic. Even if you ruin it, you can order more. It is a thinking persons appliance. Just because we are dispensing plastic does not mean we have given up our role as an orthodontist to make decisions. Just because it is in the ClinCheck and it is in the plastic, it does not mean it is going to translate to the tooth in the final equation. It's ok to go in and add things and make things predictable. It's not ok to get this plastic and give it to the patient, the tooth doesn't move and take another scan and expect something to change. That's just not going to happen until you make changes that are going to make something predictable. Dr. Jonathan Nicozisis has the cool horizontal beveled attachment that is angled that he calls the sash device. I think that is very smart. However, I have situations where I have used those, and nothing happened. So maybe it's my own stupidity and I did not treatment plan it correctly. I just

am not going to wait around for another round of aligners to fail. I am just going to put the buttons on and suck that tooth down to the right spot.

Are there any other auxiliaries you may use with Invisalign to make treatment or specific movements more predictable similar to your boot strapping technique?

First of all, I do a lot of overcorrection movements. I am one that does not show patients their ClinCheck because they will look at it and go, well my teeth are not straight. I then have to explain that this is not what will translate into their final result. Willy Dayan is great at illustrating this particular point with his open bite and deep bite cases. For deep bite cases, he is relating this to a reverse curve wire in order to intrude incisors. So for a deep bite, you make ask a technician or set it up yourself, where you may actually have a 2mm anterior open bite in the first series of aligners. It never translates to that, whether the mechanics can't do it or the patient does not wear them enough. Whatever it is, I have never seen a severe deep bite turn into an anterior open bite. All I am trying to do is get the deep overbite resolved. Therefore, I am going to build into the ClinCheck what looks bizarre to the patient. Or rotations are even over rotated to the other direction. Other things that I would do is adding the buccal root torque in the posteriors in the upper to avoid the open bites. Often times when you add torque to the upper incisors you end up causing an iatrogenic posterior open bite at the mesiobuccal cusps of the first molars. It's disheartening. It happens in extraction cases but happens in non extraction when you add lots of torque. So I ask the technician or I build it in, to give me 2-3 degrees of mesial root tip on upper first molars or extrude the mesiobuccal cusps of the upper first molars. Either instruction will get you kind of where

you want to be. Then I will look at the contacts in the occlusal view and I want red contacts of the upper first lower mesial to the lower. You would also like more significant posterior contacts when you are looking to open an anterior deep bite anyway. That's helping to get the intrusion in the incisors. I also use a lot of miniscrews. If I am going to do retraction or distalization, I am going to use class I elastics from the tray and I'll cut a notch with our tear drop. I prefer that notch to what Invisalign does. Then hook a rubber band back to a miniscrew between the upper first molar and second bicuspid. I do a lot on the palate with miniscrews too but its real common for retraction to use that type of elastics arrangement or to use it as a preliminary step in preparation for Invisalign. I may use a Carriere with a unilateral crossbite [Class II?]. I may use a miniscrew for that so I am counteracting the negative consequences of a Carriere, which is stressing lower anchorage, the unpredictability of elastics wear, and also extrusion of the canine. So if you combine the elastic which is going up to the mini screw from the canine area, going back to maxillary first molar mini screw, then class II elastics, the actual vector of force is distal. Sam Daher had a student at St. Louis University, last name Klein, they did a Master's Thesis on how much distalization of the first molars he achieved and he only used elastics to do sequential molar distalization and that's important. That it is done sequentially. He found that, I believe, that it was less than 2mm. So for minor Class II's or even pseudo Class II's where you are also building in derotation of the first molars, which is also distalization of the first molar, its great for that. But beyond that, then you are going to have to add something more. For me, that bilateral would be my horseshoe jet with miniscrews to distalize prior to retraction of the remaining teeth, or the Carriere is fine, but I would use it with miniscrews. Once you are done with that, I would go to

Invisalign and keep the miniscrew. I would then run my elastic to the miniscrew to the notch in the Invisalign so the space closure in the patient is still controlled with anchorage. Because the minute you take that off, now all the forces are back, and you're going to lose what you gained.

You talked about distalization, so if you did want to distalize with the Invisalign appliance itself, would you do it sequentially or would you do it en masse?

I would recommend sequential. It's interesting that no one yet has complete answers as to the effectiveness of en masse compared to sequential molar distalization with braces. That would be my next field of endeavor. Can we en masse distalize everything from the palate with screws? I don't know. So far we have just been focused on just moving the molars back and being satisfied with that. Because the key to distalization in a growing individual isn't the distalization. It's what is happening later. It's the interruption of dentoalveolar compensation. So I think just distalizing the molars in a growing patient is fine. The rest of it, yea you are going to close the spaces up, but the growth differential and the change in the dento-alveolar is allowing for the change to occur. It's not growing mandibles. For an adult, that is a different animal. I think you are still going to have to do sequential distalization. So to answer your question, if I am doing a teen and I think I can get it with just the Invisalign and elastics, I am not going to ask for the surgical jump. I am going to do sequential molar distalization with class II elastics. If I am questioning if whether I am getting there, I'll put the screws in and pull off those to make it predictable.

Would you say you would maximize at half a cusp or half a unit?

Probably because a half cusp class II is a pseudo class I. Any rotation may get you there. That and a little class II elastics. The next thing you may want to follow up is what do you think of these fixed functional appliances that are going into Invisalign? To me the Twin Block thing makes no sense. I do not think patients are going to tolerate that. If they are coming in for Invisalign, they are looking for a no hassle mechanism. They are always surprised that you have attachments and you have screws, elastics, or buttons. Adding in something that is that big and bulky, I am not sure they are going to go for that. As far as the Mara type thing, which is really Angle's. Angle came up with that and if you look back in history, Angle has created almost everything we ever did before we did it, except for mini screws but I bet he would have done it. Once again, it seems like a pretty bulky thing to add in. I don't know what the comfort level is. I am guessing it might be effective but you are going to see people putting them in before correcting the over bite. Then all you are doing is just ramping them up on their incisors. What's going to hold them in position. That was the difficulty with fixed functional appliances in the past. You get that instantaneous correction or in 6 months you may get some correction, but then you are going to have to hold the cuspatation in order for that to, as Johnston would say, pay the mortgage back with growth in the mandible, condyle, or whatever else is going into that. I don't see how that's going to work out yet. If you don't fix the over bite first, and a lot of people use fixed functionals as a precursor to braces, but they have braces then to hold that with rubber bands etc, with Invisalign you don't have that. In fact, you have limited intercuspation. I think what makes more sense is to have flat planes and class II elastics.

You did mention, which is the other part of treatment, the vertical dimension, including anterior open bites and deep bites. Is there anything you incorporate? What do you feel comfortable treating with Invisalign? What's more predictable?

I have seen all the experts that have presented on open bites with Invisalign and putting 2 chunks of plastic between the posterior teeth to create that iatrogenic posterior open bite. That all makes sense. Certainly in the past, with braces, or pre braces, there have been folks that have used two bite splints in the back to try and open the bite. They have use repelling magnets and found out that just using the plastic was as effective as just using the plastic. But it's again bulky. So it makes sense that you would get some posterior open bite to close the anterior open bite. I like Willy Dayan's approach to thinking about this to intrude upper posteriors at the start, and lower posteriors except for the second molars. So you are increasing the curve of Spee on the lower. I just don't trust that to always work. I am one who is always looking for predictability. So I will add in a boot strap if you will putting mini screws on the buccal and lingual of say the first molar, and using elastic over the trays to reinforce that mechanism. You may need to do that in the lower as well because if you have intrusion of the upper, the lower molars erupt and you get no change except for in the occlusal plane. So I have done that as well. The way I would set that up is put the mini screws between the molar and second bicuspid, or first molar and second molar, or buccal shelf like Chris Chang, then cut out notches at the line angles or embrasures of 1st molar, second bicuspid, second molar and using those notches to hook rubber bands down to the mini screws. You are therefore getting intrusive forces in both arches. In these cases I think you are getting some intrusion but also extrusion in

the anterior. Some folks say hey that's unstable, and I get that, but at least its improving the predictability in getting something closed. Especially in todays atmosphere where you are not going to get many people to do surgical treatments. Does it work as well as braces? That's been a claim because of the nature of Invisalign as a posterior intruder and braces as a posterior extruding appliance. It just sort of happens that way. I can't say for certain if it's better or worse. Again they are just tools. If a patient wants Invisalign and is adamant about not wanting braces, I am going to do what I can to get the best results in the most predictable manor. If that includes modifying the Invisalign itself or adding things in like buttons, elastics, mini screws, or sectional braces, fine. I am an orthodontist. That's what I do. It's not just dispensing the plastic that a technician gave me.

When you are planning to intrude the posterior teeth, do you have a certain amount or something you look for as you are relying on the auto rotation? Or are you observing as it moves along?

I think I am more observational than by going by absolutes. Kind of like Willy Dayan, I have seen him ask in the ClinCheck, lets intrude upper second molar by 3mm, the first molar by 2mm, the lower bicuspid and molars by a couple mms, in this first stage and expect some auto rotation and adjust from there. So the next series of aligners would be to further those mechanics or change some of those aspects. Of course he has different kind of attachments to support those mechanisms. It's not just a cookbook like hey; I am going to do it this way every time. There has to be individualization for each patient in how much am I going to extrude the incisors, etc. The one thing that disturbs me is when I see attachments put on almost every single tooth. Why are you doing that? Why didn't

you just put on tooth colored braces or just braces? If I was a patient, I would say why did you put something on every one of my teeth when that's not what I came in here for? Okay I got plastic, but I got this other stuff on my teeth. If I have to resort to that on every tooth, I'd be second guessing why I would want to do that.

The other part to the vertical, we talked about the anterior open bite, is treating a deep bite case. Do you have difficulty or predictability in treating those and if so, what are you using in your ClinCheck or attachments?

What I am trying to do is make the plastic work like a reverse curve wire. Better yet, a utility arch, selectively intruding the anterior teeth. You need to make a decision. Are you intruding uppers or lowers? I never liked using bite turbos but using those bite ramps makes some sense especially since they are constantly being adjusted by the system as the teeth are being separated. I have patients where I have placed anterior mini screws and placed elastics to buttons to support that mechanism and improve the predictability. I use a lot of miniscrews for intrusion with braces, upper and lower. The problem I have had most recently is I see so many adults that are wearing their incisors off because of restricted envelope of function. So they not only have a deep overbite, but they have incisors that tipped lingually. This constricted envelope is not something that the technicians even address and the setups end up with the teeth still in contact. When we were testing the torque ridges in the Invisalign teen study, I thought this maybe our answer. Just add a lot of torque. I think the answer to the torque ridges is they work just fine if you put a lot of torque into the system. I think part of it is that we asked for a lot of torque in that study, and so we got more torque. You're still not translating as much

torque as you're telling them so there is a lot of over correction in the torque. What's happening is the teeth are still in contact. So I have these adults where we have somewhat opened the bite but they are still touching and their teeth are still tipped back. I used to ask for serious amounts of torque in the upper incisors. Now I am asking for serious amount of labial crown tip in the upper incisors. In fact, if the patient looked that the ClinCheck, they would go, oh my god, I look like Bucky the Beaver. I don't have an answer yet as to how that is going to translate. But I have a series of these patients that are generally male, that I right now just started them all doing this because I said to all of them, your teeth are straight but I'm not satisfied with the results. So now we are going to see. You are my guinea pigs. We are going to see if I can get what I am looking for to help prevent you from wearing your teeth off.

You talked about adding a lot more labial crown tip, to help with the deep bites. Would you then add some intrusion of the incisors as well?

The intrusion has generally gotten fixed. But it would actually happen that if this treated out, the bite would actually open because the teeth are tipping out. So I am not asking for a whole more of that. I just want to get clearance for the incisors. A lot of these are also males that have worn their teeth down and need restorations and the dentist has no clearance. You are trying to provide enough room for them to do restorations of those incisors that everything has collapsed down. I am doing the same thing with braces. It's more predictable at this point with braces, but it's probably because I was only asking for the wrong tooth movement. I just thought the torque would handle it, but it's not. Some of them, it's give me 8 degrees of lingual crown torque and 8 degrees of labial crown tip.

Or I will just do it myself. I am creating a 2-3mm overjet in a cartoon. Is it going to translate? I don't know. I am warning the patients, if it starts looking funny, we are going to stop.

Thank you very much. I think we hit all the points I was looking to get to. Is there anything you want to add that you think maybe I missed?

I think that the point is that you can modify these trays. I am not the first one to come up with instruments to modify plastic but to produce forces to correct rotations and to help aligners track. That's why I came up with the two pliers in the clear collection from Hu Freidy that are meant to accent. You don't have to heat them. It's a small indent. One of them is vertical and it's to produce basically the same thing as a torque ridge but it can be used to increase the retention of aligners or retainers. It does not have to be Invisalign. It can be any system. It can also be used to accentuate that bubble for the attachments. If an attachment is starting to lose tracking, you accent that indentation there under the attachment, so it is reengaging the attachment or increasing that contact point at the attachment. The other plier is a vertical plier for rotations generally or to increase retention at a line angle. It is designed again to apply a force, say in a tooth that is not quite fully derotated, and it has not fully tracked all the way in the tray. You can apply a contact point and rotational couple mesial and distal or lingual and buccal. You are trying to avoid having to do a refinement for a single tooth that needs additional attention. We are modifying trays in the morning. Since we are seeing Invisalign patients all day long, even though I am still mostly braces. They are set out in the morning with a prescription sheet that I came up with that tells me where these cuts are going to go and what are we

attempting to do with them. I am not trying to pull this off the treatment chart or trying to remember what I am trying to do for each patient. I will have that patient's prescription sheet with the pliers I need and this could be done by a staff member, but I still do it myself, and I go through and I modify the trays myself for the patient that is going to be dispensed that day. Its not every patient that has modification to the trays but there certainly seems to be a lot of them because we are just looking to make things that Invisalign does well even better and more predictable.

APPENDIX D

DR. BRIAN AMY TRANSCRIBED INTERVIEW

What is your comfort level with treating cases with Invisalign?

Very comfortable with just about anything. It's more about cooperation. I used to be very focused on the idea of difficulty levels. Watching out for crowding cases. Things like that because Invisalign couldn't treat it quite as well but Invisalign got the new plastic and optimized attachments that make all of those easier. It's all about picking the right patient. Not the malocclusion. If it's a surgery case, if it's a deep bite case, if it's a heavily crowded case, that doesn't worry me. Is the patient dedicated to doing it? So I walk into every exam now thinking it could be an Invisalign case. It's just trying to determine if this patient is capable of doing it. Are they dedicated enough to actually wear the trays, then you can overcome anything. If it's an extraction case, maybe you have some tipping problems maybe later on in which you need a segment to upright it. But if the patient is excited about it, they are not going to have a problem with that. I think my goal would be 80-90% of my patients with Invisalign. But the reality is there are an awful lot of people out there that say I'm not going to wear the trays. Then we have a big discussion about cooperation. We are going to need cooperation with wearing the trays, or brushing your teeth, what you can and can't eat, pokey wires. That's still cooperation. So pick your evil. Some patients still pick braces sometimes. It could be because of colors. Some people still want it. I do not know if that is a regional thing.

You did mention extraction cases and some problems that you might experience with tipping. So is there anything you may build into your ClinChecks that may help prevent that tipping from occurring?

Sure, of course there is the G6 protocol. It already has anti-tipping optimized attachments built into it. Doing gable bends early on. A good extraction case has crowding to begin with. Because if it is not crowded, it is going to be strict closure and instead of just getting rid of some of your crowding by just alignment. So crowded cases, when you do extraction, some of your space closure is by strict alignment. I think the biggest trick for me is if I have a crowded case, with braces you level and align right away with the wire. If I have a premolar that is out of alignment and I extract the 5 because maybe the 4 is out of alignment, I won't align it because you have this great push surface mesial. So I will keep it out of alignment and then get some distal root first and then bring it in. I want to take advantage of the proximal contact as much as possible to overcome that. This provides greater surface area to push prior to bringing it into the arch. So yes, virtual gable bends, taking advantage of the proximal contact, over closing the spaces if you have them.

Do you incorporate anything like overcorrection, as you are worried about the tipping? For example extra mesial root tip or distal root tip into those extraction spaces and do you have a specific amount if so?

Yes I do that but I don't have a specific amount. Dr. Tuncay used to refer to the sunshine analysis, which was instead of taking the ceph and tracing it, and getting your measurements. Instead, take it, and hold it up to the light. It's the same thing with my

ClinChecks. I might say give me some gable bends or over treat that but then I may get it back and put it where I want it. I'm not always looking at how much that was. Was it 4 degrees, was it 8 degrees? Sometimes, I'll type 5 degrees and it comes back in the ClinCheck and it does not look like enough so I'll add more to it. So we covered it all already. Labiolingual alignment, virtual gable bends, over treatment.

Will you also use a specific attachment or will you use the optimized attachments?

I love optimized attachments. There is a lot of push back from people that they don't like the optimized attachments. They want to do big rectangular attachments because they feel like it's a better grip on the tooth. But I don't need my whole hand to make this table fall over. I just need to know where the specific pressure point is. That can do that job. I am not that smart of a guy. The techs who invented it, to the guys who work to improve it too, are much smarter than me. So I like to trust the software. Trust the fact that based upon the physics of what I designed and they want an optimized attachment right there, it's probably a good idea. Then of course they have the built in space. So if the pressure is here and it has room for the tooth to move into. Whereas the rectangular attachment is squeezing side to side. It does not have that extra space or forgiveness for it to move into it. I take some off sometimes if I don't think that movement is necessary. But I much prefer those over conventional rectangular regular ones. I just feel like those are too easy to fall off track.

You mentioned it's a little easier for extraction in crowded cases versus bimaxillary protrusion. So would you still treat a bimaxillary protrusion case with Invisalign?

I would be a little more nervous about molar tipping. No matter what they do, it's still an ongoing problem. Every case I have seen they have some degree of correction required. You are doing refinements to upright a molar. You are adding a segment to get it back up again because you lost it. I have probably only done 1 or 2 bimax sort of extraction cases and neither one are ones I would want to write home about or let Uncle Orhan see. The issues are almost always molar tipping. If you have to put a segment on, you're losing your advantage of treating faster. I have yet to finish a bimax extraction case as fast as I could have finished it with regular braces. Patient is happy, and I don't think I lost money on it because your appointments are not that long but at the end of the day, it's nothing you want to brag about. I have not heard a single case where they are like this is exactly what I wanted to do. G6 is just not there. Technology wise it is, but that molar just wants to tip.

When it comes to the transverse discrepancy, are you utilizing Invisalign to address posterior crossbites or even skeletal expansion?

Not skeletal expansion. I have done an RPE and then followed up with Invisalign. I have not done one in conjunction with it. I think I am a big fan of cooperation of course. If it's a single tooth, or couple tooth cross bite, then I will have the patients wear cross arch elastic first. Correct the crossbite first and then switch over to Invisalign and make a retainer to hold it. I like elastics during treatment. Over design or over engineer your treatment to have 2-3 mm of excess expansion, but its still a horseshoe in the back. It's too flexible to effectively get there by itself so cross arch elastics during treatment or before. It's very rare that unless it's a single tooth, you can get anchorage mesial or distal

to uphold it while you push that tooth out. If you have a true crossbite and trying to expand the arch, that's hard. At least in my hands it is.

One of the issues encountered with Invisalign in regards to expansion, is you get mostly tipping. To prevent that, would you then incorporate buccal root torque, over correction or anything else?

All of that. To prevent tipping maybe put an attachment out there to help hold it. Get it out where you want it and constant labial root torque.

Is there a specific attachment you would use to allow that to happen?

Always beveled or optimized. If there is not an optimized for that, I will throw a beveled on there. As you are tipping it, it doesn't slide up. It seems to pretty effective. It hasn't been a major issue. Still cross arch elastics help a lot.

When you are incorporating overcorrection, is there a certain amount of labial root torque you may incorporate or overexpansion?

2-3mm for overexpansion but for labial root torque, it's a little bit of eyeballing making sure the root is out further than the crown. It depends on how much is needed to get it there. It is a difficult measurement for me to know exactly.

Do you ever see any other issues with expansion? For example, is it easier to obtain expansion if it were in the premolar region versus molar region?

It's easier in the premolar region for sure. Most often if it's in the premolar region, it's probably just tipping anyway. Early on, one of my favorite cases that taught me a lesson was a buccal crossbite on LL4. I was so proud of that because it went so well. It turned out because the root was where it already belonged. It was just uprighting it. If it would have been a complete translation situation, it's much more difficult. Premolar tipping is easy.

Another component to treating with Invisalign is vertical discrepancies, being open and deep overbites. What is your experience with either or your feelings on treating them with Invisalign?

I'm not worried about them anymore. Early on, of course, I was very nervous about it. But I think we are just getting a lot more with the G5 protocol. It's fantastic. I am a big believer in optimized attachments on the premolars for leveling. Early on, the best we could hope for was just a little bit of improvement. Now we are seeing a lot more improvement with deep bites. Maybe not completely perfect yet but it's getting there. It's just over engineering such as setting overbite to maybe -2 or at least a good 2mm beyond what you want. Just like you put a greater curve in the wire and not expect to get that.

When you are opening the bite, what are your mechanics behind it? Are you intruding the lower incisors and extruding the premolars?

Well it depends on the deep bite. If it is a true vertical issue like a low angle patient, I am going to extrude the premolars 90 percent of the time. I have the G5

protocol with bite ramps on the lingual of upper 2-2 and optimized attachments for extrusion on the bicuspid and then pushing lower 3-3 down.

Do you experience any other difficulties with handling a deep bite? Maybe intruding the upper incisors?

Not as much. If they set up an intrusion at all, you take it out. They will throw some intrusion on your anterior teeth even if you didn't want it.

When it comes to the G5 protocol on deep bites, what does that specifically entail?

Has the optimized attachments on the 4s/5s. It has the movement of the bite ramps. They are not static but move with treatment. Posterior expansion. When treating deep bites, I like to think what an open bite looks like and when treating open bites, I like to think what a deep bite looks like. Try and make the set up look like a deep bite. So for a person with an open bite, you are going to have this reverse curve of Spee in the front. If you upright your molars more, you will create posterior contact and open your bite a little more. Intrusion of the anterior teeth and added torque.

The other end of the vertical discrepancy is the open bite. A lot of people have been having more success or even preferring Invisalign with open bites. What is your experience with it and what are you doing that other people maybe doing or even different to help treat open bites?

I definitely don't think I am doing anything that different than anybody else. With a deep bite you put chewies in the front. Open bite put chewies in the back. It depends on

what your etiology is. If you are looking at a tongue thrusting situation and you want to extrude the anterior teeth, or are you going to try and intrude the posterior teeth.

When it comes to extruding the anterior teeth, it has been proven to be one of the move difficult movements with Invisalign. Is there anything you are using or employing to help you achieve that specific movement?

Optimized attachments. It drives me crazy when they don't give it to you. I think it's important to know the threshold of those attachments and then create the movement to get those attachments. If the threshold for extrusion of a lateral is 1mm, and you are currently only at .8mm, it's not going to be on there and if you ask for it, they won't give it to you. If you extrude the tooth to 1, and then you can respond back to your tech and now say I have 1, give me the optimized attachment. And then if you want to, you can push the tooth back up and the attachment will generally stay. I still do that quite a bit. If they are not giving me the attachment I want, I will make the movement by referring to the attachment protocols and the thresholds and then put it there. Get what I want and then put it back. Again we are trying to decide what is the etiology. Are we going to try and extrude if at all, which then doing intrusion of the posteriors 1-2mm, your beveled attachments on the premolars only if your intruding the molars to hold them as your pushing the molars, and do those first. Then chewies in the back. Optimized attachments on the incisors, meaning that you want to create some space if possible because true extrusion is difficult. If you can get relative extrusion to swing it back, it is much easier when create some space between the incisors. Then, do equal parts of extrusion and retraction.

When trying to close an anterior open bite with posterior intrusion, are you intruding sequentially? Like second molar then the first molar?

I will do that. Thinking like a deep bite is just a big thing. You are looking to create a curve of Spee. I do not want the second molar necessarily intruding. I want the first molar intruding because the curve of Spee has an up in the back, the molar and premolar in. It's difficult to try and intrude the lower second molars and first molar and the premolar all based upon anchorage off the canine and incisors. So I will use the second molar and canines and incisors as my anchorage as I push down the 4/5/6. I may go through and extrude the 7 first, and then once the 7 is up, intrude the 5/6 together. Like I said, it's all about anchorage. Your training is there to teach you that you need anchorage somewhere to hold as I try and push the 5s and 6s.

When you are treating open bites and intruding sequentially, a lot of the closure of the open bite is relied upon auto rotation of the mandible. So how do you decide how much to intrude or how much rotation you are going to get to close the bite?

It's case by case. There is not a cookbook right. I just haven't seen a case where I say this one needs 3mm, because you can put 3mm into a ClinCheck and you're not getting 3mm anyway. I will push it where I want it to be and then do it a little bit more. I am not afraid of refinements either. I think that that's fine-tuning. I don't think a refinement is a bad thing. I expect a refinement. It's hard for me to determine the amount of over engineering or over treatment one may need. If I put in 3mm of intrusion, how much am I going to get. Will their biology allow for it? I have done cases where the over

correction has lead to over treatment. Then you say oh shoot and have to back it up a little. You have to be careful with your over engineering because based upon the patient biology, age, maybe the medications they are taking which can slow down the movement, what they are going through in life. So I don't have a specific number, back your original question. It's all over treated. I look at the ClinCheck. If it's an open bite case I show the patient a ClinCheck and pay attention to the front how it's open and now its closed. Don't look in the back because you are not going to have an open bite like that.

We hit all the major categories. You have a slide set here. I did not know if you wanted to discuss maybe any other interesting things in treatment with Invisalign?

That's a big open plate. It works. But it's not automatic. Invisalign is still a corporation. They are always going to have the problem that they are trying to make money. Trying to turn a profit. I thought for sure the company was going to go out of business 20 years ago. They didn't because they continued to engineer and stay out in front. They didn't sit back and say here is plastic. They made the new plastic or smart track material, optimized force system, everything they have done to keep ahead of the game. As it is, it works. Now the science is there. It's correctable. It is just picking the right patient. Internal marketing and success brings more patients. My criteria used to be occlusion. Now it is picking the right patient because they wore the trays.

APPENDIX E

DR. ALI HUSAIN TRANSCRIBED INTERVIEW

First, what is your comfort level treating cases with Invisalign?

I am very comfortable.

Are there any cases that you don't feel comfortable treating with Invisalign?

Severe canine rotations are one of the things I think twice about or severe brachycephalic cases. I know I can treat it technically but I found it difficult in those cases.

How comfortable do you feel treating extraction cases with Invisalign?

Moderately comfortable. I have treated many extraction cases but only if the patient wants Invisalign or bust. They want orthodontic treatment but they will only accept it if it's done with Invisalign. If I do Invisalign, in those cases I always remind them that if things are not progressing well, we may have to go to braces. I give myself an out in case we hit that bump in the road.

What kind of extraction cases are those? As in what teeth are you extracting?

I'm very comfortable with lower incisor of course. I know that's not what you consider a standard extraction case. But it will be four bicuspids, class I malocclusion. I am not going to do a differential extraction. For example upper 4s and lower 5s where

there is a class II malocclusion on top if it. There has to be a standard class I severe crowding case. That would be in my comfort zone.

Would you consider a bimaxillary protrusion, upper/lower 4s maximum retraction type case?

I don't think I have done. It's usually a case where the crowding is so much that by just extracting teeth, a lot of the extraction space is resolved by just aligning of the teeth. But if it's mostly a space closure case and maxillary retraction, I would probably push for braces.

Do you experience any difficult in treating those extraction cases with Invisalign? Like tipping of teeth or any other complications you may encounter?

The biggest thing is getting the roots parallel from the extraction site. So if you take out upper 4s, I'll find that the 3s will want to tip into that extraction site and the root won't want to move distally. So we counter that with long vertical attachments and move that methodically. Overcorrection is built into the system big time. That is the main challenge I have. Just as with braces, you can dump the bite in, you can lose anterior torque. You can end up with a lateral open bite. All the normal side effects of space closure.

When you say long attachment and over correction, specifically what kind of attachment will you use and what kind or amount of overcorrection will you utilize?

When I write up the case, the canines I will do a long vertical attachment and I almost always use the traditional. I do not use the optimized. They will set up the case with optimized but I will often remove them especially for extraction cases whether it is lower incisor or a traditional four bicuspid case. The teeth that are adjacent to the extraction case, ie the upper fives and the upper threes I will over converge at least 15-20 degrees that canine distally. That way I know it will counteract that tipping that can occur. I will also add at least 20 degrees of labial crown torque on the upper anterior and lower anterior teeth of course based on how much they started with. Obviously, if they are bimax already, I am going to ask them to maintain. And that maintenance, means you are still losing. But if its normal position, I will add 20 to maintain.

Will you bring it back one tooth at a time so you can “cup” the tooth or will you do retraction en masse?

Well I will typically do it en masse. If it is extremely crowded, I will unbreak the crowding first. Now remember if it's a 4 bi case and its severe crowded, if the patient is up to it, another thing I use to close the space, is I will put button cut outs say on the five and the three and the six and the three and I will put little buttons on the teeth and I will run power chain as well. Since it is so gingival, you will get a little tipping since you are closer to the center of resistance. That's another little cheat I use. You can use clear buttons so they are not so obvious.

Do you do anything else to control bodily movement or the tipping that you might expect?

Not typically. I have done a few tricks if I want to retract the teeth and they have a moderately to deep bite. I don't want the aligners to get trapped on the lower incisors so I will do bite turbos and sometimes I will even put them of the posteriors like you would in real life with traditional ortho. Of course you can put it on the lingual of the upper anterior but the problem with that is it's going to tend to lose some anterior torque. So you can play with VBOs or virtual bite turbos to open the bite. That's the only other trick I use.

Do you see a difference between the maxillary and mandibular arch in closing extraction spaces?

In terms of speed or tipping, I don't know. I never really compared the two. I would say that it's probably easier to control the torque in the lower. Generally smaller roots with often times you're a little class II so you are not retracting the lower anterior as much as you do the upper. So to me, there is more potential loss of anchorage in the upper just as you see in regular braces. The other trick is if you are trying to create torque, I used to always the power ridges. Honestly, I have not had much luck with them. I put them on and I have not seen any improvement. If I really want to hold torque, I put attachments on the anterior teeth. Sometimes I will even place them on the lingual, but mostly on the labial just to support the torque.

What kind of attachment would you use for that?

I'll put a square attachment but it's beveled to the incisal so that's going to give you that torque.

Another that has to be treated in a malocclusion is the transverse. So what is your experience in treating transverse discrepancies with Invisalign?

I am very modest with my expectation with Invisalign because of course when you are treating a patient with a shallow bite and even a deep bite and they are an adult without growth, the only thing you can get is tipping. So I try to set the stage. If they are a full crossbite adult and they are functioning well, I maybe move the bicuspids out for esthetics, but let's not try and bring the molars into full crossbite correction. Maybe we can improve it but if we take the crossbite and make it edge to edge, we are making more problem for the patient. They will bite their cheeks and make them uncomfortable. If its edge to edge and I feel like I can do it, they key is to of course over exaggerate the correction, perhaps by tipping the lowers in lingually and the uppers our labillary but especially on the upper, you want to make sure you are not hitting the palatal cusps. That is what leads to the posterior open bites. You have to, if you add posterior expansion, you have to add at least 15-20 degrees labial root torque to maintain that palatal intrusion. When you do your set up you want to over intrude that palatal cusp because they will always get you.

Will you incorporate intrusion or will you get that intrusion purely with buccal root torque of the expanded teeth?

In the sense you are doing intrusion because you have the material holding your vertical as well. In some ways it's easier than if you did a quad helix because when you do a quad, you are just going to push the teeth out and almost like a tripod, you are going

to be hitting the palatal cusps. With this you can work on the torque better. You have to put a labial attachment on the molars to not only move the teeth out but you have to push the teeth down on the buccal to get that torque. Sometimes you have to put lingual attachments to get a couple.

What kind of attachments would you use and how much torque will you incorporate?

About 20 degrees of torque, depending on the case of course.

Will you incorporate over correction or would you expect to see that amount of torque?

We are not going to achieve anywhere near that 20. We are using that just as a marker because in those cases, anytime I am doing unpredictable movements, I just tell the patient from the beginning that the crossbite correction is not stable and it may relapse but that is why we are going to be modest with our expectations. However, that requires refinement so any movement like extractions, crossbite correction, rotations, torque, because they are not predictable with Invisalign like braces, I feel like I have to build in at least 1-2 refinements. They need to know that even though they have 30 or 50 sets, this is just the “get me onto the green.”

You talked about lingual attachments as well. What kind of attachments would you use for those?

Same but just the opposite of the labial. So for the labial, I will put a horizontal beveled to the gingival and for palatal, it would be the opposite, beveled to the occlusal. Again, I don't do palatal attachments very often but if I really want to go for that hero mode and I really want to over expand the case, that's what I usually do because that torque is the most difficult part. To get that full bodily movement of the molars is very difficult with Invisalign.

Do you feel that Invisalign is able to resolve a posterior crossbite that is a full buccal segment or single tooth or more specifically in different areas?

I would so say no way full segment crossbite. I would not feel comfortable with it. I would rather do a SARPE or a palatal TAD supported expander prior to Invisalign. But a single tooth crossbite I feel comfortable with. But the best ones are, if you look at the lower arch and there is one molar say #19 or a lower 6 that is buccally verted, those are the best because I can tuck that lower in. That's mostly what I feel is best treated. Full crossbite, I don't know if I could do that with braces. If I can't do it with braces, I would not expect to do it with Invisalign.

Would you incorporate cross elastics at all with Invisalign?

Yes, certainly you can. I can't say I've done that very often. To me if I have a crossbite of that severity, I am going to put a quad helix from the beginning or I am going to use an expander and not going to rely on Invisalign for that. At least I don't feel comfortable with that.

The last part we are going to address is the vertical dimension. What is your experience treating open and deep bites with Invisalign?

Invisalign is superior to braces in open bites. I am talking about not skeletal, but more of a dental open bite because the appliances are intrusion rather than extrusion mechanics that you would with braces.

When you are treating an open bite, how are you looking to resolve it? Intrusion of molar, extrusion of incisors?

Usually its both. I will isolate and intrude in pieces. I will intrude the second molars first, almost using the 6s as an anchor point. Then I will push the 6s up. When I push them up, it's almost like a Tweed mechanics. I will over intrude them so they are almost like a severe open bite and then once I establish that posterior segment, it will remain still with no movement. Then I will focus on extruding the anterior teeth. I will use those attachments on the anterior teeth to extrude the teeth and over correct it. If you wanted 2mm of overbite, I will say give me a 4mm overbite. That makes all the movements way exaggerated. Again, unpredictable so I set the stage with patients that we may not get complete closure and that I will need to do refinements, at least two. It's important to just set realistic expectations but I know it's going to be better than if I did it with braces.

When you talk about intruding the molars to help close the anterior open bite, then some of it is relying on autorotation of the mandible. How do you know how much to intrude and how much auto rotation will occur?

I'm using VBRs or virtual bite turbos in the posterior, mostly unfilled but I can fill them, to help me intrude the posterior teeth. Then in the set up, I will have them remove the VBRs so I can estimate how much closure I get because the VBRs are obviously going to prop the bite open. I will remove the VBRs then I can evaluate with the setup. Now, what Invisalign is not good at is really guestimating the arc of closure because they are really using static scan. Even though they can simulate the bite change, they are not using the shape of the articular eminence or a hinge axis. It is not a typodont. It is very much of a guestimate. I don't care what the software shows you, it's a fantasy but if you want to do it perfect, you would have to do it with articulated mounted models, then you can be more accurate. In real life you end up rescanning and do your best off the intrusion, see where you are and reassess. That's real life.

Will you use specific attachments when you are looking to intrude?

The virtual bite ramps on the molars and then the extrusion horizontal attachments on the upper and lower, of course depending on the smile. Then I will extrude the teeth. When I extrude the teeth generally to extrude them, kind of like the SureSmile idea, that the only time you can close the bit is when you reduce the torque. If you flare you open, if you detorque, you drop. You almost have to create a little bit of spacing on the top, which seems weird but you almost have to flare the teeth a little bit. Then when you bring it down, you can close the door. But if you have a vertical case and the teeth are not flared at all and you try to extrude it bodily, you are going to have a hard time doing that because you have no place to push it back to. I think its just using your stuff that you

learn everyday, you almost have to flare the teeth to create spaces and then step it down. That's what I do.

The other end of the vertical, instead of open is deep bites. What is your experience in treating them with Invisalign?

With deep bites, I know that most of the lectures say that it's better that braces for obvious reason. You are not breaking the brackets and all that but I use anterior bite turbos on the lingual of the upper anterior obviously to help open the bite. I build a massive overcorrected curve on the lower. I put big horizontal attachments on the bicuspid and often times the lower anterior, but definitely the bicuspid to secure the curve of Spee. You over extrude the bicuspid and intrude the lower incisors to an open bite. If they are at a deep bite, you over correct by 1-2mm. You are creating a massive open bite. Usually it's lower incisor intrusion depending on the smile obviously. It is all by overcorrection. I don't feel as confident with it because if it's a long-term case, obviously you are intruding the molars. I don't have as much personal confidence in it but when I go to these lectures, these heavy users are comfortable with it.

When you talk about intruding the incisors, you are using attachments or are you relying on the occlusion and bite ramps to help you?

Mostly the bite ramps on the upper and I don't usually put a lot of attachments on the lower anterior, but I have. That is not my typical move, but I will usually put it on the bicuspid and I will use lower incisor if I need. But often not.

Would you say most of the correction of the deep bite is leveling the curve of Spee?

Yes, correct. And some upper, of course based on the occlusion. If they have a gummy smile, then you can intrude more in the upper.

When you look at intruding in the upper, are you using an attachment or are you relying on the broad surface of the tooth itself?

Yes, mostly on the broad surface of the teeth. Again, maybe the exception is if they are a Class II div 2, and the teeth are retroclined, then I will put labial attachments on to give me some anchorage to add torque. Anytime I put in big labial torque over 10 degrees, then I add labial attachments.

Anything else that you generally like to incorporate or do or overcorrect that you would like to just add in general?

Yes with Invisalign, I like to make the number of aligners match the appointment schedule. That means if say you like to see patients at 8 week intervals. Why not make you number of aligners a multiple of 8. So why not give me 48 aligners 6 times. So you can always give them 8 aligners. If you do 12 week intervals, make a multiple of 12. Number two, when you order the aligners, always add the last three aligners without attachments. Why? You have three pairs that have no attachments that are now retainers.

APPENDIX F

DR. GERALD GINSBERG TRANSCRIBED INTERVIEW

How comfortable do you feel treating cases with Invisalign?

I started my first case in the year of March of 2000 and I treated 1300 cases until 2011 when I retired and went into teaching.

There are many different kinds of cases that people talk about treating with Invisalign. What do you see as the most difficult kinds of cases still to treat either Invisalign?

The most difficult cases would be the four bicuspid extractions.

Do you distinguish between a maximum retraction, severe crowding or would you say any kind of 4 bicuspid extraction case?

Anytime you extract teeth on the lower and need to protract posterior teeth it is extremely difficult if not impossible with Invisalign without tipping and it requires a auxiliary fixed appliances.

You mentioned a couple things being tipping and auxiliary appliances. Do you incorporate anything into your ClinCheck to help prevent that tipping?

We tried but there is no way to avoid it.

Some things that you do try or have tried that maybe have not had success with would be?

Over the years when Invisalign first started I was a early user and we tried using power hooks attached to the attachments and we tried using fixed appliances with Invisalign over it and none of them really worked. It was much better to do as much as you can with Invisalign and then finish them off with fixed. In the maxillary arch it is very difficult also to achieve pure translation between the canine and the second bicuspid. However, I have had cases where I was able to achieve that. So with patients and slow movement, I believe you can treat in the maxillary arch without much tipping.

What specifically will you use, maybe attachments or elastics, to help you achieve that translation in the maxillary arch?

We use 5mm long rectangular attachments and 2mm thick vertically placed and also we ask for slow movement. To slow down the movement and to move the roots first.

Do you have a specific amount of tooth movement you slow it down to?

I tried to get 1/10 of a millimeter per movement. I believe Invisalign limits it to .15 but I am not positive about that.

By moving the roots first, do you ask for a certain amount of root tip?

Yes. I don't specify an exact amount though. Getting back to lower extractions, because of that and in general, except for class I cases with severe crowding or bimaxillary protusion I don't extract in the lower arch.

When you spoke about auxiliaries, what specifically do you mean in reference to helping with the tipping?

Well it didn't work so we stopped using them. This was early when Invisalign was just starting and we were trying all sorts of things to upright. Also we were using a lever arm with an 016 or 16 square wire on the bicuspid to the canine and cut away a little of the aligner. But nothing really in the beginning saved anytime. It was just a matter of doing the best you can, move the teeth with Invisalign and then upright them.

Do you feel that's the same way currently with the current Invisalign?

I do. Having been retired and not doing as many cases now working only with the students and some limited elsewhere. Knowing what I know about Invisalign and the lower arch, I cannot believe that it will work.

Besides the four bicuspid extractions, would you extract any other teeth and have success with those with Invisalign?

Yes extracting in the maxillary arch is not a problem. In general I don't believe in taking out lower incisors except when there is extreme circumstances for example, periodontally involved, very small peg shaped laterals that the patient does not wish to have enlarged. Those are the only two cases that I would take out a lower incisor. Then occasionally there are other times. I have not done this however when I first started off in orthodontics in general with fixed appliances there were some people taking out maxillary second molars for distalizing and I would not object to that if the third molar is

present as a way of correcting a class II. I have not had the occasion during my teaching to do that.

When attempting to close extraction spaces, will you attempt to move one tooth at a time to close it sequentially or will you do it all at the same time?

Yes. Again when Invisalign first started this came up in the alpha group. I was in a group that was involved with research with Invisalign and how it worked to improve the appliance. We discussed that at length. We decided that it made more sense to move the teeth sequentially. To distalize one tooth at a time to correct a class II. However somewhere along the line, Dr. Dave Paquette came up with the idea that some of the forces of moving one tooth at a time versus moving en masse all added to the same. Therefore there was no reason to move one tooth at a time. All of us then tried it and failed, so we went back to moving one tooth at a time. I believe that is general the protocol now.

Generally when you look to move one tooth at a time, do you think that being able to get the plastic fully around the tooth is helping or do you think it is anchorage?

Yes. That is one of the main reasons. By distalizing one tooth at a time, you are able to cover the mesial surface of the tooth you are distalizing. It envelops the tooth and allows it to translate more than moving them all at once. Also you are using the other teeth as anchorage and class II elastics when distalizing. In general I believe there is a 2mm limit on an adult on how much you can distalize a segment.

Another aspect of treatment is the vertical discrepancy. What is your experience with treating open bites or deep bites with Invisalign?

I have had a lot of experience with both. With open bites in general, I have developed my own technique in that I use the same protocol as Invisalign in trying to intrude the posterior teeth and intrude the anterior teeth but in addition, I have usually taken an impression of the upper arch with the Invisalign tray in place and make a vacuum formed overlay on the posterior teeth to give more thickness to the aligner in the posterior area. This can be used more than several, maybe 10 appliances, before it has to be remade. By using this thicker aligner you can intrude the posterior teeth and help aid with closing the bite also. We also have attachments on the anterior teeth to extrude them as much as possible.

You referenced attachments on the anterior teeth. What kind of attachments would you generally use?

Assuming there are no rotations needed, beveled attachments with the thinner part of the bevel towards the gingival. The reason why I do that is so if the thicker part is towards the gingival and the aligner is not fitting, you are going to lose it and have to do a revision. By having the thinner part towards the gingival, you can still regain with the attachment by wearing it longer. My goal is intrusion of the posterior and extrusion of the anterior. Secondly I have used TADs on the palatal and on the buccal with circumferential elastics and some buttons on the teeth cutting away the aligners to allow intrusion of the teeth on severe cases. Thirdly, we have done surgery.

When you talk about using both molar intrusion and anterior extrusion, how do you determine how much do intrude/extrude in a ClinCheck? Not really knowing sometimes how much you may experience?

It is sort of seat of the pants. It's not measurable really.

Do you intrude the molars sequentially or will you do it all at the same time?

With using the overlay, we are intruding sequentially. The ClinCheck intrudes all the posterior teeth at once. By using the overlay we are able to achieve the goals in a shorter period of time. I have found that before I started doing that, it took forever.

Also with the molar intrusion, the auto rotation you expect to get is wait and see as well? Nothing specific you calculate into your ClinCheck?

No. Its not that precise.

The other component of the vertical discrepancy is deep bites.

All deep bites, all moderately deep bites and almost any case where the lower incisors are crowded and lingual to the upper incisors, I place a bite turbo. If there is a significant overjet, I make my own bite turbo, which means putting some plastic or using the Ormco bite turbos and taking an impression with the bite turbos in place and then removing them and the impression or scan will have the bite turbos. Ordinarily if there is not a large overbite, it will allow Invisalign to place the bite turbos and tell them where to place them.

Are you using the bite turbos to for disarticulation and do you expect to get some intrusion of the anterior teeth?

I use it for two reasons. So I don't get intrusion of the posterior teeth, which will happen with Invisalign routinely, and I use it to allow me to get clearance to align the lower incisors. I use it to intrude both the lower and upper incisors and with all of my Invisalign cases and fixed, anybody started with a deep bite, I try and finish to a mild anterior open bite.

Will you build that into your ClinCheck?

Yes. I will build that into my ClinCheck.

Is there a certain amount that you may overcorrect to?

It's not critical. I just request a mild anterior open bite.

Is there any specific attachments you maybe use to get some intrusion?

Again, the same attachments that I mentioned before with the beveled attachments or the optimized. If a tooth is rotated and they want to use an optimized attachments. As you know as I have shown in the clinic with the cases that I did, early in treatment we were using ancient attachments such as elliptical and rectangular only at that time and yet I was able to achieve some really good results. I also won the case shootout using elliptical attachments. So in my opinion with the exception of distalizing and translating, I don't really believe that the type of attachments is that important. I think that just like in

pliers, when someone has to have their name on it, in general an attachment is an attachment.

When you are talking about a deep bite, you talked about intrusion of anterior teeth. Would you ever look at extrusion potentially of posterior teeth?

In my strong belief, that nobody has ever shown that you can change the mandibular plane angle permanently. Essentially anybody who is extruding posterior teeth to correct a deep bite is doomed to failure, unless the patient is willing to wear a bite plane for the rest of their life.

Also a common issue to a deep bite is a large curve of Spee. Is there any mechanics or attachments that you incorporate into your ClinCheck that might help you level the curve of Spee?

Again, getting back to the same thing with attachments, attachments are attachments. They are pieces of plastic that you attach to the Invisalign plastic to grab it. It does not really matter what kind of attachment you are using.

Will you still make sure to maybe put some on the premolars or specific teeth?

We are using it on the posterior buccal segment to hold the aligner and the anterior segment if needed to intrude. It's a reciprocal anchorage. The curve of Spee is corrected by intruding the anteriors and leveling the posteriors. You are not going to extrude the posteriors and have success long term.

Do you feel that Invisalign is able to treat extreme deep bites, maybe with palatal impingement?

Yes. I have treated extreme deep bites with palatal impingement.

Lastly, the last dimension of a malocclusion is the transverse. What is your experience in transverse dimension with Invisalign?

A total posterior crossbite either unilateral or bilateral and, its never unilateral. Its usually bilateral with a shift can not be treated with Invisalign. I have never seen anybody show a case where they expanded with Invisalign the arch. A one tooth, a molar in crossbite, yes. Two molars, as long as the 7s are not in crossbite can be done. But to go an entire buccal segment, the aligners are much to flimsy. Now, I am willing be shown a case that somebody has done but so far I have not seen it.

What will you do or use to counteract that?

I will use most often a quad helix prior to starting Invisalign or on certain surgery cases, I would align the teeth and do a SARPE. I guess if it's a child and they are Class III, and its going to be non-surgical, I would use a Hyrax. Assuming that is really was a tremendous high angle, mouth breather with really a truly a small, constricted maxilla. As you know, I believe rapid palatal expanders are over used.

When you talk about trying to correct a one-tooth crossbite with Invisalign, what will you do or build into the ClinCheck to help you achieve that?

I would first create space around that tooth. Then use the other teeth as anchorage as I slowly expand that tooth.

Again, will you use a specific attachment?

Again, attachments don't matter. I would most often allow Invisalign to place the attachment unless I thought they were choosing the wrong attachment. Most often they would choose a beveled attachment of some kind. If it were a molar, I would probably use a rectangular attachment. One other thing about attachments, I have no reservation about putting an attachment on the lingual as well as on the buccal. Also, for rotations I would do that. Put the buccal or labial attachment off center and lingual attachment off center to the other side to create a couple.

When you speak about using it both lingual and buccal, maybe for the expansion purpose, what is the advantage of having it on the lingual?

For grabbing. I am saying I would do it on that specific instance. I would just say if I needed, the advantage would be just grabbing it more. If we are talking about a molar.

Would you incorporate any degree of overcorrection or overexpansion?

You don't need that on a one tooth because once the crossbite is corrected it is locked in. There is no need to overdo it. You must know that for every reaction there is an equal and opposite reaction. As you are expanding that tooth, you are creating a lingual force on the other teeth. Normally it is not a problem but something to watch for.

Will you incorporate into your ClinCheck overexpansion and then not expect to get it or will you put the tooth in the ideal position in your ClinCheck?

If we are talking about a single molar in crossbite, I would just bring it into the arch. I see no need to try and over expand it. Again, once the buccal cusp is buccal to the buccal cusp of the lower, it is not going to go back.

Do you feel that you get the exact movement out of the ClinCheck or do you feel that you need to put a little more and not expect to get it all?

No I don't have to. Its not that I am not a great believer in over treatment because I am on many things. But when we are talking about locking in place, there is no need to do that. On the other hand, there are not many one tooth molar cross bites.

Will you ever utilize cross elastics with it?

If it was failing of course.

You would first try with solely the trays?

If there was other things to be done. If we were treating a full case and it was not just a one-tooth crossbite that I was treating. If I were aligning the anteriors, correcting a Class II, reducing the overbite or overjet, then I would do it along with all the other treatment. Then when it came to a case refinement to the end of treatment if I have not achieved my goals, then I would do them. If you are going to use class II elastics along with the Invisalign, how are you going to know you are not getting ahead of the

Invisalign? Then affect the other teeth. Why do it if you are going to get the correction anyway.

A lot of people in general are believers in incorporating overcorrection into the ClinCheck. Do you generally do that and maybe not expect to see it in reality?

Overcorrection as I mentioned before, I definitely over correct open bites and deep bites. Class II, you are lucky to correct the Class II let along over correct it. Crowding, no. I don't overcorrect crowding.

Maybe root torque or rotations?

No. Root torque, you are not going to.

I am referring to maybe what is in the ClinCheck set up versus reality is what I am truly getting at?

Let's talk about root torque. You'd be lucky to get root torque anyway. And by the time you're at the end of treatment, if you are lucky enough to have corrected a bicuspid extraction and have the roots relatively parallel, if you want to try root torque and I have not. I have only had one case in all my cases, and I did not extract that much, where I truly was able to get the roots parallel with Invisalign only. I have had several cases where it was close enough and the patient was satisfied. Then I had many cases where I had to use sectionals even in the maxillary arch. But that was early on before the stiffer aligners. I still believe overcorrection of rotations, you are not going to overcorrect because how are you going to make a retainer.

When I say overcorrections or how people talk about it with Invisalign, they say in the image it is overcorrected but it never gets to that point in reality. Do you ever see that need for that specifically?

It serves no purpose. If you are over correcting the rotation maybe 5-10 degrees, and your aligners are fitting, you are going to finish with overcorrection 5-10 degrees. The aligners are not fitting, then in reality, you did not get it. If you have corrected the rotation then you have corrected the rotation. If you are worried about relapse, you've got to use a retainer that is going to stop the relapse, but if you over rotate then what do you do next? Do you make a retainer with the over rotated teeth? The thing to do, is correct it and hold it. You can overcorrect one thing, which is spacing. The aligner can't go past the contact.

Is there anything you may like to add in reference to Invisalign treatment?

Yes. Attachments. In real life you are going to find people saying "You are going to put what on my front teeth?" You explain that you are going to put these attachments on because you are going to hold the aligner. However they will say that they came here because they wanted to look good during my treatment and I don't want those things on my front teeth. The answer is you put them on the lingual on those patients and it works.

My question for it is are more people doing that or how come Invisalign is not promoting that more often?

I don't know. Its just I had a large Invisalign practice and I had a lot of difficult human beings who were very demanding. Some of them were in the public eye and they did not want anterior attachments.

Do you think that the lingual attachments work just as well as if they are on the facial?

Probably not but they do work. Eventually they work. For example, instead of not filling the bite turbo, you could fill it. That is a great attachment. Also, for rotations, they work.

Why do you think they may not work as well?

Because of the lingual surface is curved. You have a problem with biting on them and things like that. But it works and you will find that depending upon the economic level of your practice, you're going to find people like that. Right now we are in a clinic and people have to do what we say. But in real life, things are different. I have heard many people say that now that we have these new attachments, its making it a lot easier. I don't see that. Perhaps a little bit but its not critical.

I would also like to talk about IPR. Since we are limited to 2mm of Class II correction in an adult, sometimes Class II corrections require more than 2mm. Posterior IPR between the 6/7, perhaps .5mm or you have got guts maybe even a little more, and between the first molar and second bicuspid. We are not worried so much about class I molar but we want class I canine relationship. Posterior IPR something I am in favor of. For anterior IPR, I don't want to create a Bolton discrepancy so when I teach, if there is

no Bolton discrepancy and you want to do IPR in the anterior area, on the lower incisors, because they are really crowded, then you want to do an equal amount on the upper incisors otherwise you are creating a Bolton discrepancy and vice versa. If you create the Bolton, you now have an overjet, which is going to cause a deep bite in the end.

I would also like to talk about a shift. As you know, as I have taught that whenever you see the mandibular midline off to one side, think shift. I do not know what the percentage, but its probably somewhere between 70-90% of all mandibular midline discrepancies are a result of a midline shift. Therefore, when you are doing your ClinCheck or you are making your request to Invisalign, you are having them correct the midline shift not moving the teeth around. You want your class II elastics equally on both sides. You also want to find which tooth is causing the midline shift, which is the interfering tooth. You have to expand that one.

According to Invisalign, 60% of all ClinChecks are accepted without revision. In my experience, even with the most experienced technicians at Invisalign, changes need to be made. In my experience, I have gone up to eight revisions on once case before I have accepted it. The average is 3 or 4. Technicians, although they are very good, they are not orthodontists and they don't know enough about orthodontics to be able to do it, even with your notes.