CLEAR ALIGNER TECHNIQUE

Sandra Tai, BDS, MS

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Sandra Tai, BDS, MS, FRCD(C)
Clinical Assistant Professor in Orthodontics
Graduate Orthodontics
Faculty of Dentistry
University of British Columbia

Certified Specialist in Orthodontics
Private Practice
Vancouver, British Columbia

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DEDICATION

To my parents, Kim and Shirley, whose unwavering faith, hope, and love have been a pillar of strength for me through the peaks and valleys of my life's journey.

To Dr David Gunaratnam, who inspired me to become an orthodontist and to give my life away in the service of others.

To Dr T. Michael Speidel, who gave me a chance and told me that my life would never be the same again.

To Dr Robert Boyd, a trailblazer and visionary in the field of clear aligner technique.

CONTENTS

FOREWORD

This textbook is a must-have reference for the dentist or orthodontist who performs clear aligner treatment in his or her practice. There is of course heavy emphasis on the Invisalign appliance because of its longevity in the field and dominance over the past two decades as the appliance becomes capable of more advanced tooth movement.

The book starts out with a review of fixed appliances versus clear aligners and details the evolution of clear aligners as a natural progression forward in our understanding of how to do optimal orthodontic treatment. The book continues with chapters explaining the various tooth movements that can be accomplished with clear aligners, with a comparison of edgewise appliances and clear aligners as far as their capabilities. The book follows with a comprehensive explanation of how the Invisalign software (ClinCheck) is used for planning and executing treatment once a correct diagnosis and treatment plan have been made. Special attention is paid toward understanding how teeth should move optimally and what movements are more difficult versus those that are more predictable.

The book then shifts to troubleshooting, finishing, and retention as well as all the different types of tooth movement possible with clear aligners. Many practical suggestions are made, including when overcorrection versus overtreatment is indicated. There is even a chapter that goes in depth into orthognathic surgery treatment planning for conventional orthodontic treatment first versus surgery-first treatment. The final chapter has an excellent discussion of interdisciplinary treatment that integrates restorative and occlusal functional issues with esthetic concepts.

By far the most outstanding contribution of this book is its straightforward and clear writing. Dr Sandra Tai is undoubtedly a very talented orthodontist, an experienced teacher at all levels, and an excellent writer. All of the case examples used are of the highest-quality photography and show the latest and most efficient methods of clear aligner treatment.

I strongly recommend that this new book be part of your reference library.

ROBERT L. BOYD, DDS, MEd
Professor, Department of Orthodontics
Arthur A. Dugoni School of Dentistry
University of the Pacific

PREFACE

Clear aligners are the future of orthodontics. However, due to rapidly evolving advancements in the field of digital orthodontics, any text is soon outdated, perhaps even by the time it goes to print. The challenge is to write a book that will keep up with the evolving technology and still be a good resource for anyone learning basic orthodontic principles and clear aligner technique. This text does just that, approaching clear aligner treatment from a diagnosis and treatment-planning perspective. It discusses time-tested orthodontic principles like biomechanics, anchorage, and occlusion and explains how to apply them to treating orthodontic cases with clear aligners. These principles should stand the test of time even as technology evolves and the appliance changes.

This text is intended to be a reference handbook on clear aligner technique. Orthodontists, graduate orthodontic students, dentists, and dental students will find this to be a valuable resource in learning how clear aligners work as an orthodontic appliance, as the text lays down basic principles for clear aligner technique. The bibliography section includes the most recent publications in clear aligner research.

The text is also designed to be a clinical handbook. When a clinician plans to treat a particular case with clear aligners, it is my hope that he or she will refer to the chapter pertinent to the malocclusion present and, based on the information there, be able to *(1)* arrive at a proper diagnosis, *(2)* program in a suitable treatment plan, *(3)* design the digital tooth movements to match the treatment goals, and *(4)* execute the treatment clinically, troubleshooting when complications arise and applying techniques to finish the case to a standard of excellence.

As we learn to harness the power of the digital world to move teeth and design occlusions to a degree of accuracy we never thought possible, let us not forget that at the very core of our profession of orthodontics, we are changing smiles and changing lives.

THE FUTURE IS CLEAR.

ACKNOWLEDGMENTS

"Appreciation is a wonderful thing. It makes what is excellent in others belong to us as well."

— Voltaire

I would like to express my deep appreciation to all who had a part in making this book a reality. To the friend who first suggested that a binder containing my lecture notes looked like it could be a textbook; to my sister, Anne, who made sure I kept on writing; to Catherina, who encouraged me to approach Quintessence for publication; to a friend who bought me a special pen to autograph my book as an expression of faith; and to others who encouraged me, believed in me, and supported me in immeasurable ways.

I would also like to express my gratitude to Dr Charlene Tai Loh for her invaluable assistance in putting together the bibliography section; to Dr Brandon Huang, who covered clinical work for me when I had to write; and to the incredible team from my private practice who excel at photographic technique and patient care, including Stephanie Sarino, who sent me photographs and radiographs any time day or night.

Finally, to the doctors all over the world who attended my lectures and asked if the information I presented would be found in a book, thank you for your inspiration, for your encouragement, and for pushing the boundaries of innovation together with me.

1 A BRIEF HISTORY OF THE ORTHODONTIC APPLIANCE

IN THIS CHAPTER

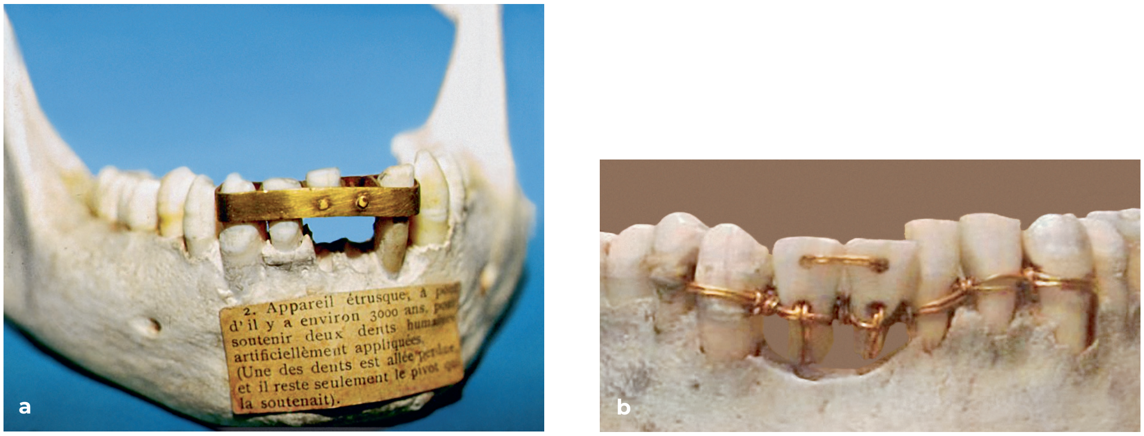

Fig 1-1 *(a and b)* Excavations from the Etruscan period showing metal bands and gold wire ligatures splinting teeth together.

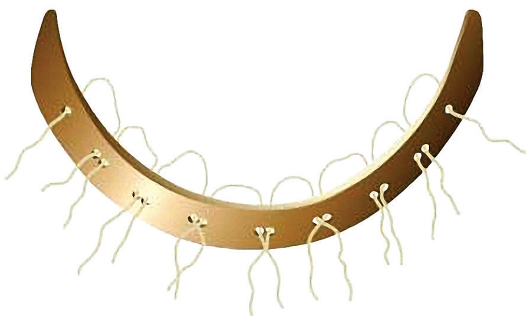

Fig 1-2 Fauchard's bandeau.

Fig 1-3 Pin and tube design of the "ribbon arch" appliance.

FIXED APPLIANCES

The history of orthodontics dates back more than 2,000 years, making it the oldest specialty in the field of dentistry. Around 300 to 500 BC, Hippocrates and Aristotle reflected on different ways to straighten teeth and address various other dental conditions. Excavations from the Etruscan period revealed human mandibles with wire ligatures and bands splinting teeth together (Fig 1-1). In 1728, Pierre Fauchard, also known as the "father of modern dentistry," published a book called *The Surgeon Dentist*. In the chapter on orthodontics, he proposed a horseshoe-shaped piece of precious metal that helped to expand the dental arch, known as *Fauchard's bandeau* (Fig 1-2). It was ligated to the teeth with wire ligatures and expanded the dental arches to move the teeth into alignment.

In 1901, Edward Angle founded the first school of orthodontics in St Louis, Missouri. Angle devised a simple classification for malocclusion that is commonly used today. In the early 1900s, fixed appliances were known as the "ribbon arch" appliance and consisted of gold bands formed around individual teeth with brackets soldered onto the band (Fig 1-3). Wire ligatures and pins were used to secure the archwire to the bracket. Precious metals that were soft and malleable such as gold and silver-nickel alloy were used.

By the 1950s and 1960s, these once relatively expensive bands were being made out of stainless steel (Fig 1-4). Full-arch banded appliances remained the norm until the innovation of direct bonding allowed orthodontists to directly bond a bracket onto enamel. At that time, the fixed edgewise appliance was known as a "zero-degree" appliance. The orthodontist had to

Fig 1-4 Full-banded stainless steel appliances.

Fig 1-5 Andrews's straight-wire appliance with brackets directly bonded onto teeth. (Reprinted with permission from Alexander RG. The Alexander Discipline, vol 3: Unusual and Difficult Cases. Chicago: Quintessence, 2016.)

Fig 1-6 Lingual bracket system.

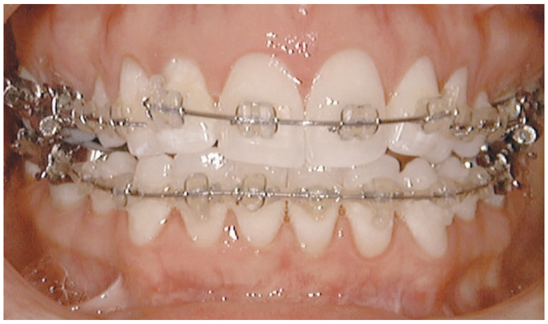

Fig 1-7 Ceramic brackets. (Reprinted with permission from Alexander RG. The Alexander Discipline, vol 2: Long-Term Stability. Chicago: Quintessence, 2011.)

make first-order (in-and-out), second-order (tip), and third-order (torque) bends in the archwire to finish the occlusion.

In 1970, Dr Lawrence Andrews proposed building the in-and-out, tip, and torque into the appliance itself, either into the bracket base or the bracket slot. This eliminated the need to make bends in the archwire. This became known as the "straight-wire" appliance and remains the standard of fixed appliances used today (Fig 1-5). There are now many different bracket prescriptions with varying degrees of tip and torque available. Clinicians may choose the bracket prescription of their preference depending on their orthodontic philosophy and the treatment mechanics employed to move teeth.

In 1975, two orthodontists, one American and the other Japanese, independently developed a bracket and wire system that could be placed on the lingual surfaces of teeth. "Lingual braces," as they were known, became an esthetic alternative for patients who did not want the brackets to be visible. Lingual bracket systems have also evolved over time to include digital computer imaging to assist with custom-fabricated bracket bases and archwires (Fig 1-6).

As the quest for a more esthetic orthodontic appliance progressed, sapphire and ceramic brackets became available in the early 1980s (Fig 1-7). Around the same time, new archwires with elastic and thermal properties such as nitinol, titanium molybdenum alloy (TMA), and heat-activated nickel-titanium eliminated the need to make complex loops and bends in the archwire. Today, there is a plethora of variations of the standard twin bracket available in different prescriptions, as self-ligating or non–self-ligating, and made of metal, plastic, ceramic, or sapphire.

Fig 1-8 Clear aligners.

As we trace the evolution of the orthodontic appliance over the last 100 years, we can see a distinct shift toward an orthodontic appliance that is more esthetic, is more hygienic, occupies less surface area on the teeth, and is able to accurately move teeth into the final occlusion with compatible biologic forces.

CLEAR ALIGNERS

The history of clear aligners may be traced back to 1945, when Dr H. D. Kesling first proposed a clear, vacuum-formed tooth-positioning appliance for minor tooth movement. It was a labor-intensive process that required manually repositioning teeth reset in wax, and a clear vacuum-formed retainer was made for every tooth movement in a series of stages until the teeth were aligned. This technique was capable of minor tooth alignment. However, the amount of labor required for the task precluded its use on a wide scale, particularly for correction of more complex malocclusions.

Another half-century went by until two graduate students at Stanford University in 1997 applied three-dimensional (3D) computer imaging graphics to the field of orthodontics and created the world's first mass-produced, customized clear aligner system. This new technology revolutionized the world of dentistry and orthodontics, launching it into the 21st century.

There is a distinct difference between evolutionary change and revolutionary change. Evolutionary change comprises incremental changes that take place gradually over time. The evolution of fixed appliances represents variations and incremental improvements on a bracket and wire system that has taken place over the last 100 years. Revolutionary change, in contrast, is transformational change. Revolutionary change is profound, dramatic, and disruptive. Revolutionary change challenges conventional thinking and requires a radical paradigm shift in our mindset. Clear aligner technology represents a revolutionary, transformational change in orthodontics that challenges the conventional thinking of how orthodontists move teeth. However, the advent of clear aligner technology does not mean that 150 years of orthodontic principles are no longer valid. The time-tested principles and concepts of bone biology, biomechanics, anchorage, and occlusion still apply. However, in this 21st century of digital technology, the clinician must now learn to apply those principles of orthodontics to the field of clear aligner technique.

Clear aligners have already evolved since they were released to the market in 1999. In the early days of clear aligners, most clinicians understood them to be an orthodontic appliance that was suitable for the treatment of Class I cases with minor crowding, resolved primarily with interproximal reduction. Today, clear aligners from Align Technology are made of a new tripolymer plastic and make use of optimized attachments (Fig 1-8). The teeth are moved according to sophisticated computer algorithms developed in the software program. There are many clear aligner systems being developed all over the world, and it is evident that this will be the future of orthodontics.

It is important to understand that **clear aligner treatment is a technique, not a product**. There is a common misconception that clear aligners are a "compromise" orthodontic appliance that is only capable of minor tooth movement. However, the clear aligner system of today is a *comprehensive* orthodontic appliance, capable of treating a wide range of malocclusions. The remaining chapters of this text discuss the principles of clear aligner technique and lead the clinician through a process of learning how to apply the principles of orthodontics to clear aligner technique.

FUTURE DIRECTIONS

As we look toward the future evolution of orthodontics, the ideal orthodontic appliance could be conceived as a custom-made orthodontic appliance, made to adapt to individual tooth morphology and anatomy. It would be customized to move each individual tooth with exactly the amount of force required to move it based on the tooth morphology and root surface area. It would have customized biomechanics and would be able to adjust the rate of tooth movement according to the individual's bone physiology. The final occlusal outcome would be customized according to the individual's dental arch form, smile esthetics, and soft tissue lip support. The tip, torque, in-and-outs, and occlusal contacts could be designed uniquely for each individual. This ideal appliance would be esthetic, hygienic, and comfortable and would accomplish correction of the malocclusion in the shortest time frame possible.

In reality, the future evolution of orthodontics has already arrived in the present, as clear aligners utilize digital technology for diagnosis, treatment planning, and designing the final occlusal outcome. To a certain degree, it is possible to customize the biomechanics by staging tooth movements in a specific sequence in the software program. The rate of tooth movement may also be adjusted according to the individual's bone physiology by altering the scheduled number of days for aligner changes, depending on the individual's response to tooth movement. The final occlusion set up in the software may be customized according to the individual's dental arch form and preferences for smile esthetics.

So if the future is already here, where do we go from here on? As orthodontists, it takes courage to step outside our comfort zone of the familiarity of brackets and wires to embrace a new orthodontic technique. It takes vision to challenge the status quo of conventional orthodontic thinking. It takes innovation to think of new ways of moving teeth. Finally, it takes diligence and time to produce well-designed scientific research in the field of clear aligners so that we may continue to practice clinically sound, evidence-based orthodontics. The future lies in continuing to innovate with passion to transform the future of our profession.

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2 A COMPARISON BETWEEN EDGEWISE APPLIANCES AND CLEAR ALIGNERS

IN THIS CHAPTER

TABLE 2-1 Patterns of force, engagement, and anchorage in fixed appliances versus clear aligners

	FIXED APPLIANCES	CLEAR ALIGNERS
Force	Exerts a "pull" on teeth	Exerts a "push" on teeth
Engagement	Archwire into bracket: The thicker the wire, the better the engagement	Plastic around teeth: The more plastic wrapped around teeth, the better the engagement
Anchorage	Reciprocal anchorage: Newton's third law	Anchorage segments may be predetermined

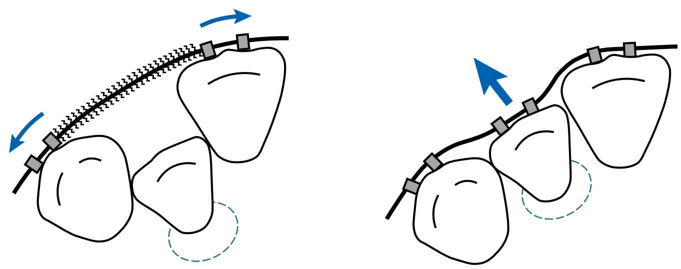

Fig 2-1 As the archwire reverts to its original form, it pulls the lingually erupted tooth into the dental arch.

Clear aligner treatment is an orthodontic technique. As such, the orthodontic principles of force application, engagement, anchorage, and biomechanics need to be applied to clear aligner technique. However, clear aligners move teeth differently than fixed appliances do. Therefore, a clear understanding of the similarities and differences between fixed appliances and clear aligners is essential for the clinician when making a decision whether to treat a case with fixed appliances or clear aligners. Clear aligners are uniquely suited to treat some malocclusions more efficiently than fixed appliances, offering better vertical control and superior management of anchorage considerations. Knowing the strengths and weaknesses of clear aligners as an orthodontic appliance will assist the clinician in selecting the best orthodontic appliance to address a specific malocclusion.

FORCE, ENGAGEMENT, AND ANCHORAGE

Table 2-1 compares the force, engagement, and anchorage of fixed appliances and clear aligners.

Force

A fundamental difference between the way a bracket and wire system moves teeth and the way clear aligners move teeth is that fixed appliances *pull* on teeth while clear aligners *push* on teeth.

Figure 2-1 shows that when an archwire is engaged onto a lingually erupted tooth, the elasticity in the archwire causes the archwire to return to its original arch form. As the archwire returns to its original shape, it pulls on the lingually erupted tooth to move it into the arch.

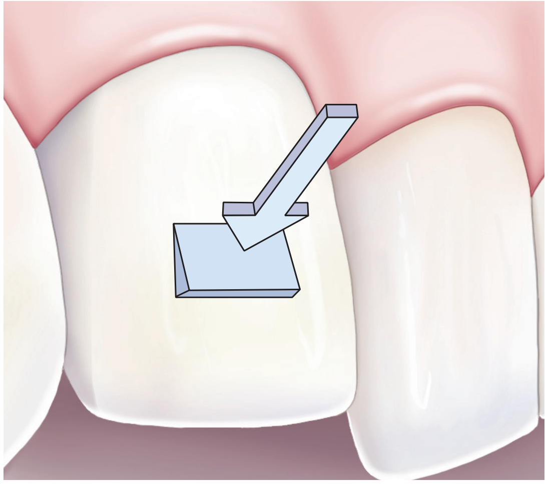

Fig 2-2 Clear aligners push against the flat surface of an attachment to move teeth.

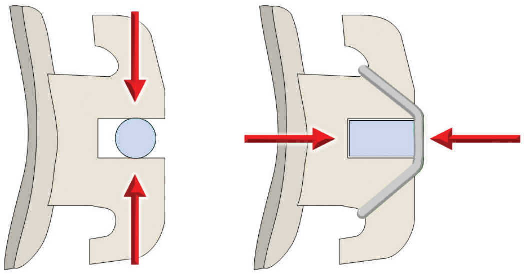

Fig 2-3 The round, flexible initial archwire engages the tooth to move it into position. A full-size rectangular archwire fully engages the bracket slot so that the torque and tip built into the bracket slot will express clinically. (Reprinted from Burstone CJ, Choy KC. The Biomechanical Foundation of Clinical Orthodontics. Chicago: Quintessence, 2015.)

The force applied to the tooth is dependent on the flexibility of the archwire and the amount of deflection it undergoes to engage the tooth. Similarly, in space closure with fixed appliances, an elastomeric chain is stretched to engage the teeth across the space, and when the elastomeric chain contracts and rebounds to its original shape, it pulls the teeth together and the space closes.

In contrast, clear aligners move teeth by exerting a push force. When an aligner is inserted over teeth, there are minor differences between the positions of the teeth intraorally and the positions of the teeth in the aligner. The aligner deforms over the teeth, and the elasticity in the aligner material pushes the teeth into position. Optimized attachments provide an active, flat surface that the aligner may push against to effect tooth movements such as extrusion or rotation (Fig 2-2).

Engagement

Fixed appliances engage teeth via an archwire ligated into the bracket slot. The thicker and more rigid the archwire, the better the engagement. The archwire sequence starts with round, flexible archwires with a long working range and high elasticity and gradually moves toward rigid, rectangular stainless steel archwires. In an archwire that approximates the size of the bracket slot, the tip, torque, and in-and-outs that are built into the bracket slot or base will be more fully expressed (Fig 2-3).

Clear aligners engage teeth by having aligner material wrapped around teeth. The more aligner material wrapped around a tooth, the better the engagement. In teeth with long clinical crowns and larger surface area, there is better engagement and therefore better expression of tooth movement (Fig 2-4a). Conversely, in teeth with short clinical crowns and less surface area, there is less engagement and less expression of tooth movement (Fig 2-4b). One way to increase the engagement of the aligner onto teeth with small morphology—for example, peg-shaped lateral incisors—is to place an attachment on the tooth. This increases the surface area of the tooth and therefore increases the engagement of the aligner to help the tooth movement express clinically. Similarly, in cases where sequential distalization is planned, it is critical to register the distal surface of the distalmost tooth in the arch so that the aligner can fully engage that tooth to distalize it.

Anchorage

In fixed edgewise appliances, the most common anchorage model is that of reciprocal

Fig 2-4 Long clinical crowns *(a)* provide better engagement for clear aligners, while short clinical crowns *(b)* offer less engagement.

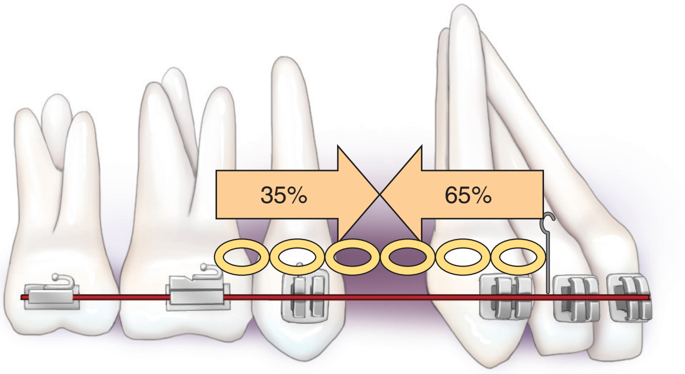

Fig 2-5 The concept of reciprocal anchorage in fixed appliance extraction space closure.

anchorage, based on Newton's third law: For every action, there is an equal and opposite reaction (Fig 2-5). One segment of teeth will act as an anchorage unit for another segment of teeth. For example, in first premolar extraction site closure, the posterior teeth act as an anchorage segment for the anterior teeth. At the same time, the anterior teeth act as an anchorage segment for the posterior teeth. Because the root surface area of the posterior segment is larger than that of the anterior segment, the anterior segment will retract more than the posterior segment will move forward. The forward movement of the posterior segment is called a *loss in anchorage* in orthodontics. This loss in anchorage is often taken into account by the clinician when treatment planning extraction cases to ensure that the buccal occlusion finishes in a cusp-to-fossa relationship in the final occlusion.

In clear aligner treatment, the anchorage segments can be predetermined and may change at different stages in treatment. In this respect, clear aligners offer extremely good control of anchorage because the anchorage teeth may be made immovable at different stages of treatment. For example, in the staging of sequential distalization of the maxillary arch, only the second molars are distalized in the initial stages of treatment. The remaining teeth in the arch from first molar to first molar do not move in the initial stages and act as an anchorage segment to push the second molars distally for anteroposterior correction (Fig 2-6).

In the G6 first premolar extraction protocol (Align Technology), for maximum anchorage, only the canines and posterior teeth move in the initial stages of treatment. The incisors do not move, and they act as an anterior anchorage segment to distalize the canine into the extraction site for space closure. At a certain stage in treatment, the second premolar and molars stop moving, and they become the posterior anchorage segment as the canines and incisors are retracted for the remainder of the extraction site closure (Fig 2-7). Patterns of anchorage are more fully discussed in chapter 13.

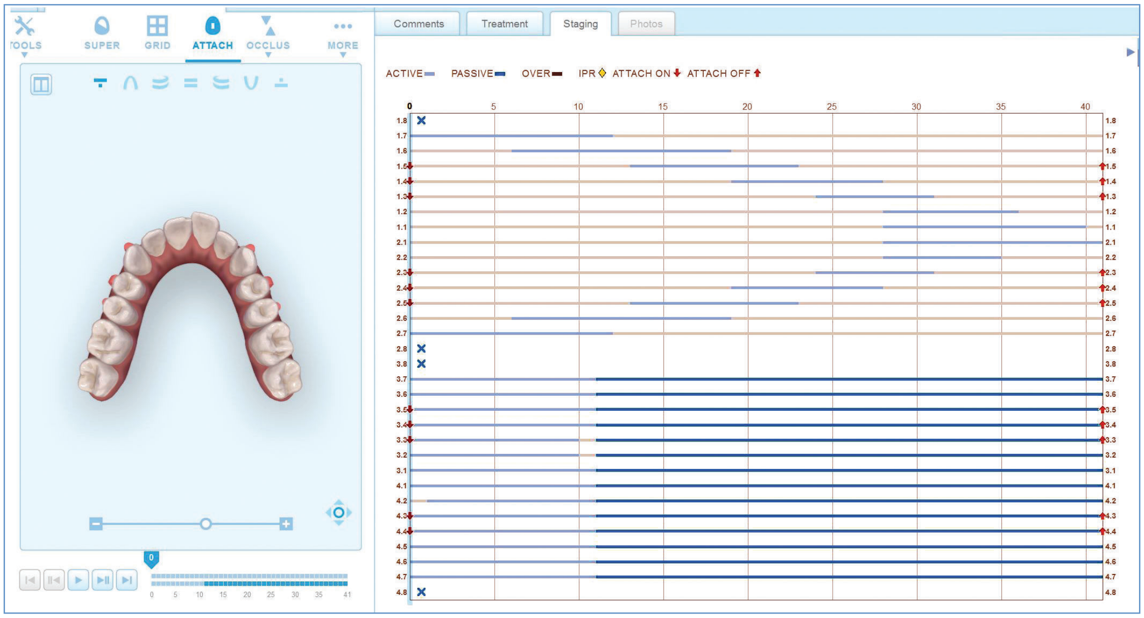

Fig 2-6 Staging pattern for sequential distalization of maxillary molars. From stage 1 to 12, only the maxillary second molars are moving. The rest of the maxillary teeth from first molar to first molar act as an anchorage segment.

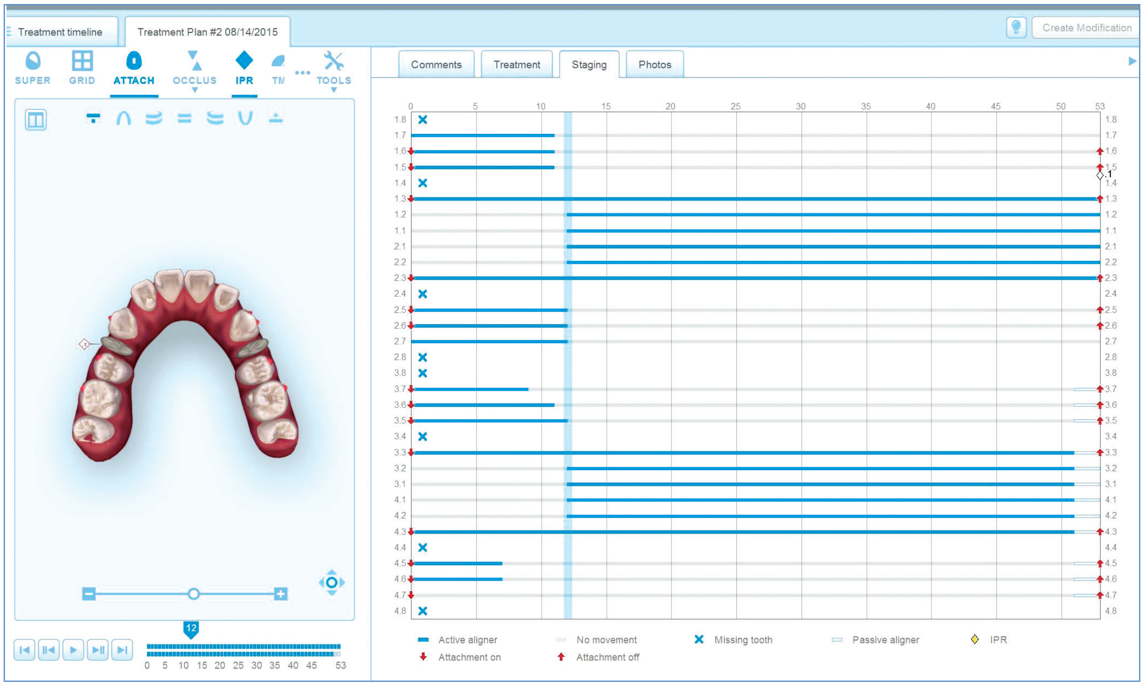

Fig 2-7 Staging pattern for G6 first premolar extraction space closure. In the initial stages of treatment, the incisors do not move and act as an anchorage segment to push the canine distally into the extraction site. After stage 14, the posterior teeth no longer move and act as an anchorage segment for continued retraction of the canine and incisors for extraction space closure.

TABLE 2-2 Capabilities of fixed appliances versus clear aligners in terms of extrusion, intrusion, torque, and root inclinations

	FIXED APPLIANCES	CLEAR ALIGNERS
Extrusion	Single tooth	Anterior segment
Intrusion	Relative intrusion only	Entire segments or selective intrusion
Torque	Labial and lingual root torque	Lingual root torque through power ridges
Root inclinations	Control of root inclinations through bracket positioning and archwire bends	Control of root inclinations through optimized attachments and virtual gable bends

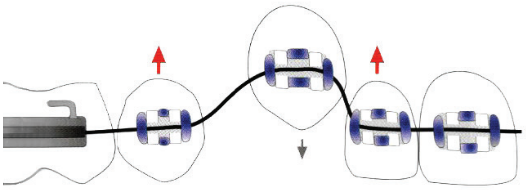

Fig 2-8 With fixed appliances, extrusive force on the canine produces intrusive forces on the adjacent teeth.

Fig 2-9 Extrusion of maxillary incisors with multi-tooth optimized extrusive attachments to close an anterior open bite. (Reprinted with permission of Align Technology, Inc.)

EXTRUSION, INTRUSION, TORQUE, AND ROOT INCLINATIONS

Table 2-2 compares fixed appliances and clear aligners in terms of extrusion, intrusion, torque, and root inclinations.

Extrusion

In fixed edgewise appliances, extrusion of a single tooth may be accomplished relatively easily. However, because all the teeth in the arch are connected by an archwire, there are reciprocal movements of the adjacent teeth. For example, in a case where a buccally erupted canine requires extrusion, as the canine extrudes, the adjacent lateral and central incisors and first premolar will intrude (Fig 2-8). This may create a temporary cant to the occlusal plane. Eventually as the treatment progresses into more rigid archwires, the occlusal plane will level out. In the event reciprocal tooth movements are undesirable, a rigid archwire may be placed to stabilize the occlusal plane, and a flexible twin-wire overlay may be placed to extrude the buccally erupted canine.

Extrusion of a single tooth is a moderately difficult tooth movement for clear aligners, depending on the amount of extrusion required. At times, some auxiliary treatment such as buttons and elastics may have to be placed to assist with single-tooth extrusion. However, extrusion of groups of teeth, for example when maxillary incisors are extruded to close an anterior open bite, may be performed successfully with clear aligners (Fig 2-9).

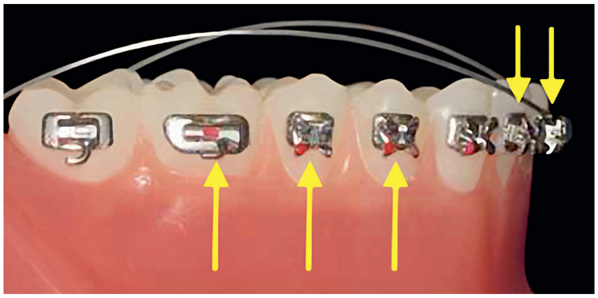

Fig 2-10 Relative intrusion with a reverse curve in the archwire.

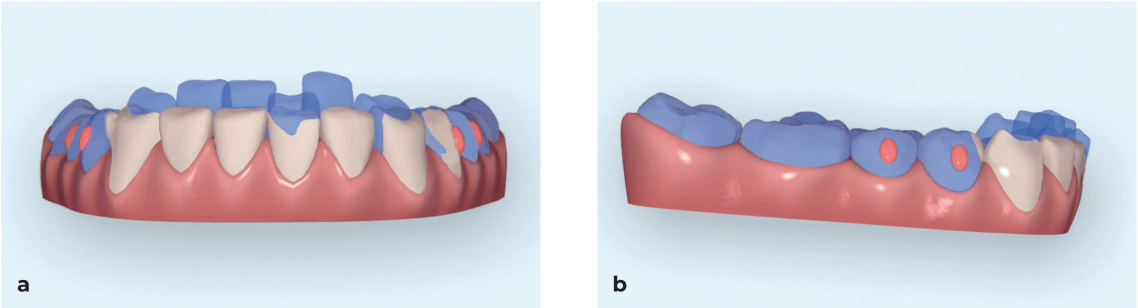

Fig 2-11 *(a and b)* Superimpositions in the software program showing anterior intrusion to level out the curve of Spee.

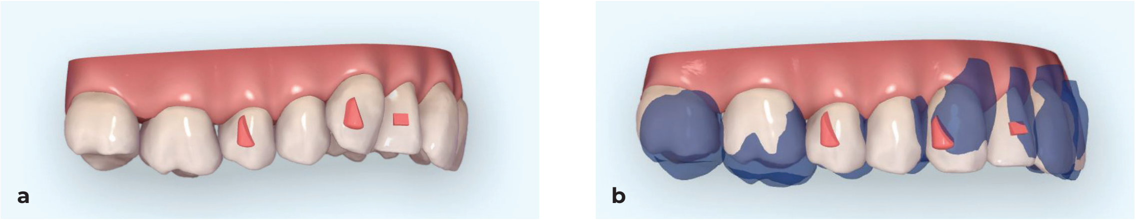

Fig 2-12 *(a and b)* Superimpositions in the software program showing posterior intrusion to create occlusal clearance.

Intrusion

In fixed edgewise appliances, dental arches are leveled through relative intrusion with reverse curves in the archwire (Fig 2-10). As the anterior teeth intrude, there is some concurrent extrusion of the posterior teeth. Alternatively, segmental intrusive base arches may be used with careful management of the posterior anchorage through transpalatal or lingual arches or high-pull headgear in the maxillary arch to manage any unwanted reciprocal extrusion of the posterior segments.

In clear aligner treatment, entire segments of teeth may be intruded successfully, or selective intrusion of individual teeth may also be programmed to correct an occlusal cant or level out gingival margins. This may be performed without concurrent extrusion of the posterior segments if so desired. As a result, clear aligners offer extremely good vertical control. In Fig 2-11, anterior intrusion is programmed to level out the curve of Spee in the mandibular arch to correct a deep bite. In Fig 2-12, posterior intrusion is programmed to create occlusal clearance after the posterior teeth have hypererupted.

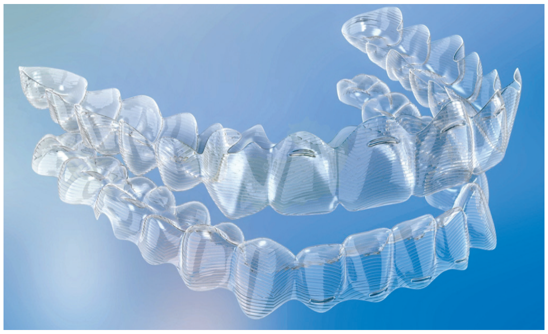

Fig 2-13 Power ridge feature for incisor torque on maxillary and mandibular incisors.

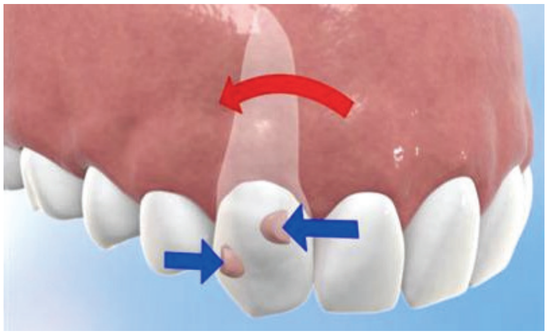

Fig 2-14 Optimized root control attachments for control of root inclination. (Reprinted with permission of Align Technology, Inc.)

Torque

In fixed edgewise appliances, torque is built into the bracket slot. The amount of torque expressed is related to the size of the archwire and the amount of torque built into the bracket slot. There are varying torque prescriptions for different bracket systems. Some clinicians will use different torque prescriptions for individual patients depending on the initial malocclusion. Additional torque may be added by making torquing bends in the archwire. However, where there is a size difference between the archwire and the bracket slot, the wire has an angle of freedom to move within the bracket slot; this is commonly known as *play*. This element of play between the bracket slot and the archwire is responsible for the fact that the actual torque expressed will always be less than the torque prescription in a fixed appliance system.

Clear aligners offer the power ridge feature for lingual root torque (Fig 2-13). The incisor torque in the finished occlusion may be predetermined for individual patients depending on the initial malocclusion, desired final occlusion, and soft tissue lip support. Clear aligners are very efficient in managing incisor torque where excessive torque is not desired. Excessive torque may be undesirable in cases with mild incisor protrusion that are treated nonextraction, with maxillary incisor torque in lower incisor extraction cases, and where the incisor mandibular plane angle requires careful management. However, just like with fixed appliances, there is an element of play between the aligner and the teeth, making the actual torque expressed clinically less than that prescribed. Therefore, in extraction cases where some loss of incisor torque is anticipated, additional torque should be built into the final occlusion in the software. Management of the interincisal angle is discussed in chapter 6, while managing loss of incisor torque in extraction cases is discussed in chapter 13.

Root inclinations

In fixed edgewise appliances, tip is built into the bracket slot. If further adjustment to root inclinations is required, then root-tip bends may also be made in the archwire. Once again, there may be some play between the bracket slot and the archwire that precludes the full expression of the tip built into the bracket slot.

In clear aligner treatment, optimized root control attachments offer control of root inclinations (Fig 2-14). Long, vertical rectangular attachments will offer control of root inclinations as well. In lower incisor or premolar extraction cases, virtual gable bends may be requested to ensure careful management of root inclinations as the extraction spaces are closed.

TREATMENT MECHANICS

Table 2-3 compares fixed appliances and clear aligners in terms of incisor inclination, vertical control, midline correction, and tooth size discrepancy.

Incisor inclination

In fixed appliance treatment, incisors tend to procline on alignment. Clear aligners, on the other hand, offer excellent control of incisor

TABLE 2-3 Capabilities of fixed appliances versus clear aligners in terms of incisor inclination, vertical control, midline correction, and tooth size discrepancy

	FIXED APPLIANCES	CLEAR ALIGNERS
Incisor inclination	Incisors tend to procline on alignment	Excellent control of incisor inclination
Vertical control	Overbite and overjet decreases with incisor proclination and alignment	Excellent vertical control in cases with minimal overbite and overjet
Midline correction	Dependent on elastic wear	Predictable
Tooth size discrepancy	Needs to be calculated or adjusted for midway through treatment	May be accurately calculated using ClinCheck software

inclination. In addition, the ClinCheck prescription form offers the option to indicate that no proclination is desired. The labiolingual pre- and posttreatment positions of the maxillary and mandibular incisors may also be monitored using the superimposition tool to ensure that the incisor inclinations and labiolingual positions are maintained in the posttreatment occlusion.

Vertical control

In fixed appliance treatment, overbite and overjet tend to decrease as the incisors procline during alignment. This may be favorable where the initial malocclusion presents with a deep bite with increased overjet. However, it may be unfavorable if the initial malocclusion presents with minimal overbite and overjet.

Clear aligners offer excellent vertical control in cases with minimal overbite and overjet. The occlusal coverage of the aligners on teeth as well as the ability to program intrusive mechanics into the treatment plan allow for leveling and alignment with excellent control of the vertical dimension.

Midline correction

Intraoral anterior cross elastics are commonly worn with fixed appliances for midline correction. This is dependent on patient compliance and is often frustrating for the clinician when the midline fails to correct, as the anterior elastics are challenging to wear.

Midline correction with clear aligners is more predictable, as interproximal reduction is commonly incorporated into the treatment plan to correct the dental midlines. If the midlines are corrected in the final occlusion seen on the software treatment plan, they are very likely to be corrected clinically.

Tooth size discrepancy

In fixed appliance treatment, an anterior Bolton tooth size discrepancy is usually calculated or adjusted for midway through treatment. Typically, this happens when the clinician has difficulty closing spaces in the maxillary arch or moving the canine into a solid Class I relationship. To resolve this discrepancy, a decision must be made between leaving space around the relatively smaller lateral incisors or compromising the buccal occlusion and leaving the canines in a mild Class II relationship.

In clear aligner treatment, the treatment-planning software accurately calculates the tooth size discrepancy and will resolve it according to the clinician's preference, either by leaving space around the lateral incisors or by including interproximal reduction in the opposing arch. This is decided at the treatment-planning stage and built into the final occlusion.

CONCLUSION

The differences in mechanisms of tooth movement between fixed edgewise appliances and clear aligners discussed in this chapter should give the clinician an idea of how to apply the principles of orthodontics to clear aligner technique. When making the decision as to what orthodontic appliance is best suited to resolve a malocclusion, the clinician should be aware that the decision is not a matter of choosing between an esthetic appliance and an unesthetic appliance. The choice is not between two different materials of plastic versus metal. It is a decision between different mechanisms of action to move teeth.

Traditionally, orthodontists are trained to be reactive. An adjustment is made to the appliance and, based on the patient's treatment response and the resultant tooth movement, another treatment decision is made at the next appointment and the archwire adjusted accordingly. Each treatment decision is made reactively, based on the treatment response to the adjustment to the orthodontic appliance made previously.

Clear aligner technique requires a more proactive, disciplined approach. Before a single tooth is moved, the correction of the malocclusion is visualized through a series of tooth movements made on a software program and the final occlusion designed into the treatment outcome. This requires a paradigm shift in the thought process from being a reactive orthodontist to being a proactive orthodontist.

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