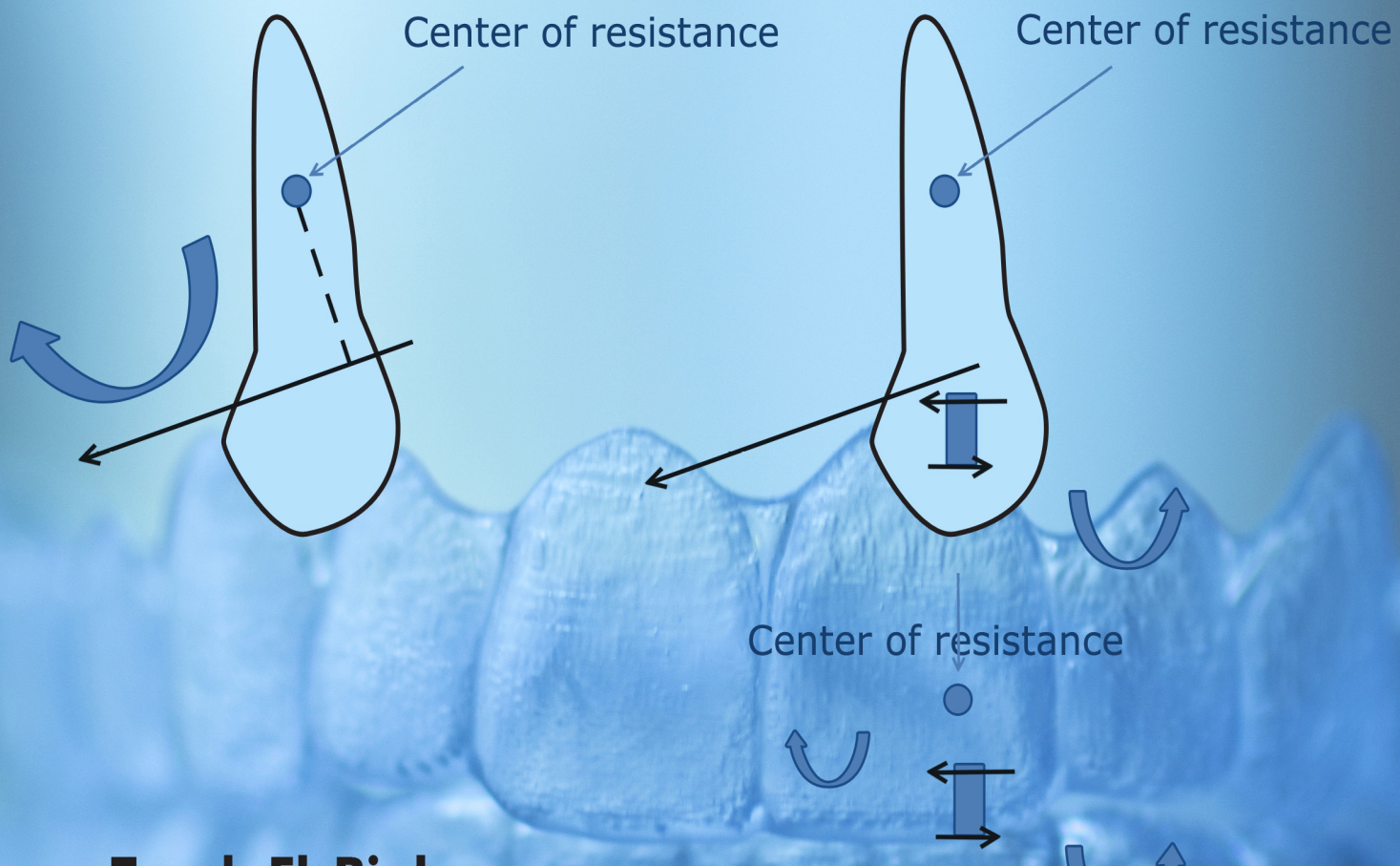
eISBN: 978-1-68108-311-7
ISBN: 978-1-68108-312-4

eISSN: 2468-5046
ISSN: 2468-5038

RECENT ADVANCES IN DENTISTRY

VOLUME 1

ORTHODONTIC BIOMECHANICS: TREATMENT OF COMPLEX CASES USING CLEAR ALIGNER



Tarek El-Bialy
Donna Galante
Sam Daher

Bentham Books

Recent Advances in Dentistry

(Volume 1)

Orthodontic Biomechanics:

Treatment of Complex Cases Using Clear Aligner

Authored By

Tarek El-Bialy

Faculty of Medicine and Dentistry
University of Alberta
Edmonton, Alberta T6G 2E
Canada

Donna Galante

6526 Lonetree Blvd. Suite 100
Rocklin, CA 95765
USA

&

Sam Daher

Daher Orthostyle
1555 Marine Dr #204
West Vancouver, BC V7V 1H9
Canada

Recent Advances in Dentistry

Volume # 1

Orthodontic Biomechanics: Treatment of Complex Cases Using Clear Aligner

Authors: Tarek El-Bialy, Donana Galante & Sam Daher

ISSN (Online): 2468-5046

ISSN (Print): 2468-5038

ISBN (eBook): 978-1-68108-311-7

ISBN (Print): 978-1-68108-312-4

advertisements or ideas contained in the Work.

Limitation of Liability:

In no event will Bentham Science Publishers, its staff, editors and/or authors, be liable for any damages, including, without limitation, special, incidental and/or consequential damages and/or damages for lost data and/or profits arising out of (whether directly or indirectly) the use or inability to use the Work. The entire liability of Bentham Science Publishers shall be limited to the amount actually paid by you for the Work.

General:

1. Any dispute or claim arising out of or in connection with this License Agreement or the Work (including non-contractual disputes or claims) will be governed by and construed in accordance with the laws of the U.A.E. as applied in the Emirate of Dubai. Each party agrees that the courts of the Emirate of Dubai shall have exclusive jurisdiction to settle any dispute or claim arising out of or in connection with this License Agreement or the Work (including non-contractual disputes or claims).
2. Your rights under this License Agreement will automatically terminate without notice and without the need for a court order if at any point you breach any terms of this License Agreement. In no event will any delay or failure by Bentham Science Publishers in enforcing your compliance with this License Agreement constitute a waiver of any of its rights.
3. You acknowledge that you have read this License Agreement, and agree to be bound by its terms and conditions. To the extent that any other terms and conditions presented on any website of Bentham Science Publishers conflict with, or are inconsistent with, the terms and conditions set out in this License Agreement, you acknowledge that the terms and conditions set out in this License Agreement shall prevail.

Bentham Science Publishers Ltd.
Executive Suite Y - 2
PO Box 7917, Saif Zone
Sharjah, U.A.E.
Email: subscriptions@benthamscience.org

CONTENTS

FOREWORD

Clear aligner therapy is one of the exciting new techniques being used in orthodontics since it was introduced in the late 1990s by Align Technology in the United States. Recently, other companies have come out with products that use a similar principle, but incorporate a different technology and use different materials. Aligner treatment was initially introduced to treat limited malocclusion and/or relapsed cases.

In recent years, there have been a number of articles about the use of clear aligners in a broader spectrum of orthodontic cases than just simple crowding or relapse cases. These publications and presentations focus more on treatment outcomes than on the related diagnosis process, treatment planning and biomechanics.

Understanding three-dimensional diagnosis and treatment planning as well as biomechanics of tooth movement are very important to clinicians who may use clear aligners to treat difficult orthodontic cases. This book outlines basic principles for using clear aligners to address various difficult orthodontic cases.

Dr. Jae Hyun Park
Arizona School of Dentistry & Oral Health
5835 East Still Circle
Mesa, AZ 85206
USA
Tel: 480-248-8165
Fax: 480-248-8117
Email: JPark@atsu.edu

PREFACE

The introduction of clear aligners in orthodontics as a treatment modality for complex and difficult cases has gained a worldwide acceptance/attention nowadays due to the increased advantages over regular fixed orthodontic systems. These advantages include, but not limited to the following; 1) Clear aligners are more esthetically acceptable than fixed orthodontic braces including clear (Ceramic or plastic systems) due to the fact that even with regular clear braces, metal wires are still being used which usually are seen from a distance and Teflon coated wires usually undergo peeling off the Teflon coat, which leads to the wire metal be seen; 2) clear aligners require less maintenance compared to regular fixed appliances, in other words, less emergency visits like broken brackets, poking wires and other associated complications with regular fixed orthodontic braces; 3) no food restriction like with clear aligners usually as with regular fixed orthodontic braces since the patients remove the aligners during meals and eat normally, brush and floss normally then wear the aligners back; 4) no human error in bracket positioning like those in regular fixed orthodontic braces. Even with sophisticated computerized indirect bonding techniques that utilize sophisticated computer softwares for bracket positioning with fixed orthodontic braces, most of the time the clinician has to do wire bending and normally finishing fixed orthodontic cases takes at least six to eight months on average, mainly to fix minor human errors in bracket positioning; 5) clear aligners can be more hygienic if the patient brushes his/her teeth normally as there is no much time needed to brush and floss around brackets and wires with regular orthodontic braces, and 6) nowadays difficult and complex tooth movements can be readily obtained by clear aligners when clinicians can utilize basic understanding of orthodontic mechanics during deigning and treatment planning cases using clear aligners. Finally, even in cases with bad oral hygiene when patients may undergo severe enamel decalcification with clear aligners, the aligners can be used as fluoride applicators to help with enamel re-mineralization. This does not mean that orthodontic treatment with clear aligners does not have challenges. Main challenges in orthodontic treatment with clear aligners include but not limited to the following: 1) Treatment efficacy, which could be mainly due to patients compliance, and this is not different in adults or teenagers; 2) challenges related to aligners' plastic materials which are continuously improving, however there is a lot to be done in research and development (R&D) for optimum results; 3) essential diagnosis and treatment planning of the cases which should not violate basic foundation of orthodontic skeletal/dental and esthetic evaluation and needs for each patient; 4) oral hygiene can be a problem if the patient does not maintain oral hygiene, clear aligners could act as a plaque incubator. This book is intended to present the authors' own experience with difficult cases including skeletal class I, Class II and Class III as well as facial asymmetry. However, before jumping into deep water, it may be wise to know how to swim in shallow water. This is what this book is intended to provide the

reader with step by step diagnosis and treatment planning in general then introduction to biomechanics in orthodontics in general, and finally cases will be presented and discussed in terms of diagnosis, treatment planning and case management. It is also to be noted that this first edition of the book is intended to present initial cases and it is expected in the next editions that more challenging cases will be presented and their treatment planning and results will be discussed. With this, I would like to thank the contributors, all my supporting staff and family for providing support in documenting these cases and also I would like to dedicate this work to my family who sacrificed long hours and days of family time so I can finish this book.

ACKNOWLEDGEMENTS

Declared none.

CONFLICT OF INTEREST

The authors of this book testify that they do not have any conflict of interest with any clear aligner company. Also, the authors do not promote any specific clear aligner company or favor one company over the others. Again, the authors present their own cases without claiming any financial rewards from any company.

Dr. Tarek El-Bialy
Faculty of Medicine and Dentistry
7-020D Katz Group Centre for Pharmacy and Health Research
University of Alberta, Edmonton, Alberta T6G 2E
Canada
Tel: 780-492-2751, Fax: 780-492-7536
Email: telbialy@ualberta.ca

Dr. Donna Galante
6526 Lonetree Blvd. Suite 100, Rocklin, CA 95765
USA
Tel: 916-287-0078
Email: drgalante@gmail.com

&

Dr. Sam Daher
Daher Orthostyle, 1555 Marine Dr #204, West Vancouver, BC V7V 1H9
Canada
Tel: +1 604-913-1555
Email: drdaher@orthostyle.com

CHAPTER 1

Introduction/History of Clear Aligners

Abstract: Orthodontic treatment without braces has been introduced more than half a century before clear aligners have been introduced in orthodontics. Clear aligners have been utilized to treat minor crowding for more than a decade. However, in the last few years, there has been increased interest and many publications came out in different prestigious peer reviewed journals about the possibility of using clear aligners to treat difficult orthodontic cases. Different companies that manufacture clear aligners for orthodontic tooth movement spent a huge time span and resources to optimize treatment results and to provide more controlled tooth movement. The research and development included, but not limited to design attachments that can provide optimum tooth control, develop new plastic material that can have shape memory in order to maximize its efficiency in tooth movement and developing protocols for different malocclusions. There is a huge global interest in using clear aligners in orthodontics, however it might take decades for traditional orthodontists to adopt clear aligners in orthodontic practice. This chapter will briefly review the available literature about the background of clear aligners and its future application in orthodontics.

Keywords: Aligners, Clear, History, Invisible, Minor, Movement, Orthodontics, Relapse, Tooth.

Moving teeth without braces has been introduced long time ago by Kesling in 1945 [1] and the concept of clear retainer was reported by many authors afterwards [2 - 6]. Great interest in using clear aligners began in late 1990s when some orthodontic patients have had some relapse and two options were presented to the patients, retreatment or using a new version of clear plastic that is used to fabricate retainer, known as Essex retainer. The older version of active Essex retainer is known as spring aligner, or spring retainer, also known as Barrer retainer because it was first introduced by H.G Barrer in 1975. As it was first described by Barrer, an impression is taken, poured in stone then teeth are

Tarek El-Bialy, Donna Galante & Sam Daher

crowded or relapsed then the teeth are cut, set then the problem is fixed the patient has (mainly re-crowding) (Fig. **1**) [7].

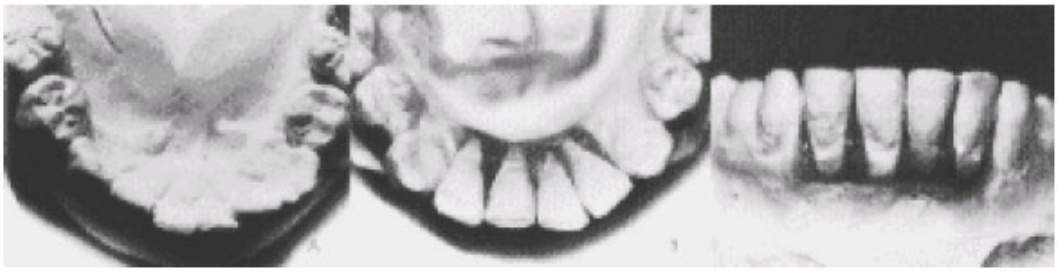


Fig. (1). Set up of the model stone to correct relapsed or crowded teeth for fabrication of spring aligners [7].

Fig. (2). Spring retainer/aligner fabricated on set stone teeth model.

Spring aligner (Fig. **2**) can be fabricated for maxillary or mandibular teeth and it was first introduced by H. G. Barrer in 1975. The mandibular appliance is mainly used today. It consists of a single piece of stainless steel wire 0.022 inch (0.56 mm) to 0.029 inch (0.72 mm) in diameter, bent around the six anterior teeth.

The spring aligner used is difficult to fabricate and hard to predict its results' outcome. When the crowding is beyond a millimeter in each contact, more than one aligner (spring aligner or Essix aligner) needs to be fabricated; this is how clear aligners started.

Not too far away, in 1993, 1994 initial reports about using Essix technology/ plastic to move teeth. [5, 8 - 10]. Sheridan philosophy is to simplify orthodontic treatment using Essix plastics and interproximal reduction, a technique that can resolve crowding as severe as to 10 mm of dental arch length deficiency and more importantly to control anchorage with other appliances [5, 8].

Invisalign or Align technology in 1999 took this idea further to utilize CAD/CAM (Computer aided design-computer aided manufacturing) technology, that can integrate digital treatment planning using clincheck software that allows the clinician to request specific tooth movement or finish and communicate this treatment planning with the technician at Invisalign. With these advances in CAD CAM technology, other companies started to appear in the market with similar technologies although the plastic used in each company could be different, and the diagnosis/treatment planning software(s) could be different between companies, the idea of utilizing clear aligners in treatment cases more than simple crowded or spaces cases can be achieved.

The first case report using Invisalign technology was presented by Boyd in 2000 for the treatment of mild crowding and space closure [11]. In a randomized clinical trial, soft and hard plastic materials were tested and changing aligners each week or two week period was also studied [12]. They concluded that all patients who completed their first set of aligners had either an additional series of case refinement aligners or fixed appliances to finish their treatment. Two-week change of aligner protocol showed a higher degree of success than 1-week change protocol. They further concluded that patients that were on the 2 week change of aligner protocol, non-extraction cases and a low PAR score were more predicted to complete their first set of aligners. Moreover, cases that had extraction treatment plans and high PAR scores showed less chances that the first set of aligners would be completed [12]. In their second study, the same group reported that the 2-week change of aligner protocol showed a larger likelihood of reduction in weighted PAR and AII scores, and higher likelihood of extraction space closure. Also, they reported that anterior alignment was the most improved part of the malocclusion, and buccal occlusion was the least improved part. They also compared treatment outcomes in lower incisor and premolar extraction. They reported that incisor extraction sites had a significantly greater likelihood of closure than any premolar extraction sites [13].

Treatment efficacy of Invisalign has been studied at different times, (2005) [14, 15] and 2009 [16], 2014 [17]. Most of the earlier reports (2005, 2009) agreed that the effectiveness of the Invisalign aligners ranged between 29.6% to 47.1% of the planned tooth movement [16]. However, the recent study by Simone *et al.* 2014

CHAPTER 2

Science and Practice of Clear Aligners

Abstract: This chapter will briefly discuss the science behind using clear aligners in orthodontics. Although fabricating aligners can be made by hand in the lab or using computer aided design/computer aided manufacturing system, the science behind using specific plastic material that has specific elasticity to move the teeth in the intended direction is still unclear and many manufacturers do not declare it as a major manufacturing or business secret. In a simple assumption, the clear aligner materials must be flexible enough to accommodate the existing tooth/teeth position and be stiff enough to move the teeth in the intended direction. Although seems simple, however it took major companies decades spending many millions of dollars on research and development to reach this particular balance. In the following section, a general review of what is available in the literature about clear aligners' materials is provided.

Keywords: Aligners, Basic science, Bio, CAD/CAM, Clear, Effectiveness, Materials, Orthodontics, Piezoelectricity, System.

Initial clear aligners fabricated to resolve simple crowded teeth due to relapse were labor intensive in doing dental stone set up for each set of aligner. When the crowded teeth require few aligners to be fabricated, a full time lab technician is required to be in each orthodontic office, or an expected lab cost of approximately $100 per set of aligner. With this, it is very costly to perform such treatment and it would be better to retreat relapsed cases with fixed orthodontic treatment. With advances in CAD/CAM system as well as the use of different plastics, many aligners may be fabricated with less lab labor however; it would require large capital for investment in research and development of computer software. In addition, challenges using CAD/CAM system as well as highly sophisticated computer software based on thousands of cases treated with traditionally fabricated aligners made huge advances in taking clear aligners to the next level

Tarek El-Bialy, Donna Galante & Sam Daher

where more difficult cases may be treated solely by clear aligners without the need to use fixed orthodontic appliance at the beginning or at the end of the cases to finish and detail the occlusion. Although the author of this book is not directly or indirectly involved in any clear aligner companies, however he has been using clear aligners in the last ten years from simple to very difficult cases.

It was hypothesized that the clear plastic that has been used initially with Essex retainers may be used solely for the treatment of difficult cases without the need for fixed orthodontic appliances at any stage of the treatment. This hypothesis is based on understanding basic orthodontic diagnosis/treatment planning and mechanics in a different way to fully execute orthodontic treatment by clear aligners.

There is no much information in the literature about the chemical composition of the plastics that are being used by different companies, including Essix, Invisalign and others to improve treatment outcome in terms of flexibility and stiffness of the plastics. This could be due to the market competition and manufacturing secrets that most companies prefer not to declare in scientific literature.

In reviewing the ideal characteristics of orthodontic wires, three main properties are needed. 1) Appropriate stiffness to minimize breakage or failure during treatment by patient handling or masticatory forces; 2) Appropriate flexibility so that wire can be tied to severely crowded teeth without permanent deformation, and 3) high range of activation so that the patient can be seen over longer intervals without the need to frequent changing their wires. Similar physical properties may be needed with clear aligners. Appropriate stiffness is required to minimize breakage of the aligners due to treatment or biting on the aligners by patients, especially in weak areas where severe crowded teeth are aggregated. Also, appropriate flexibility and shape memory of clear aligners are very important so that the aligner material can be easily flexed around severely crowded teeth and can easily grasp the crowded teeth or teeth with bulbous morphology with high areas of contour. In the event that the material does not flex enough to satisfy the above mentioned criteria, it is difficult to move teeth with clear plastic aligners. Finally, it would be an ideal property that the clear aligners material possess high range of activation or shape memory such that few aligners may be used to move

the teeth gradually at a lower physiological rate without applying too much force that may be deleterious to the periodontal ligament and alveolar bone.

Although different companies utilizing clear aligners and may be holding different patents on the composition and properties of the plastics that every company is using to fabricate orthodontic aligners, it seems to the author of this book that no such combination of these physical properties exists, at least at the current time, or provided by any of the current clear aligners companies.

A recent study evaluated physical properties of aged and retrieved Invisalign aligners [1]. The authors evaluated the aligners' structures after being used for two weeks by patients or aging in retrieved aligners. They reported that the retrieved aligners showed morphological changes compared to the as-received samples including abrasion at the cusp tips, adsorption of integuments, and localized calcification of the precipitated biofilm at areas of food stagnation. The authors also reported that buccal segments of retrieved aligners showed an increase in hardness, which the authors attributed this phenomenon to mastication-induced cold work, however this concept has not been explained in detail. The authors also commented that the clinical implication of this problem on treatment efficacy of Invisalign outcome is unknown as it has not been studied at this time. Since this study has been published in 2004, only recently Align technology reported to introduce a new plastic material that has improved physical and structural properties. However, again there is no much information available about the chemical composition of these new plastic materials.

An interesting, however has been overlooked, publication in 2003 when it has been shown for the first time that the plastic that has been used to fabricate Essex aligners/retainers has in fact a piezoelectric property and may be used as ultrasound transducers [2]. This property may be important in orthodontic treatment using these types of plastics and future research may be directed to improve such property of the newly developed plastic. One might ask why this piezoelectric property is important in orthodontic treatment. One of the fundamental theories of biology of orthodontic tooth movement is the piezoelectric theory [2]. According to Proffit [3], piezoelectricity is a phenomenon observed in many crystalline materials in which a deformation of the crystal

CHAPTER 3

Orthodontic Diagnosis and Treatment Planning

Abstract: Orthodontic treatment planning is essential before deciding what type of orthodontic treatment may be used to treat different cases. Before the development of various orthodontic appliances (standard edgewise, straight wire, self-ligating fixed bracket systems or clear aligners) one should keep in mind what are the patient's problem list, treatment objectives and treatment planning, then based on the treatment planning, mechanics can be proposed and then one can choose or not use specific appliance based on the clinician's level of comfort using such appliance. This chapter will briefly review the contemporary steps in diagnosis and treatment planning of orthodontic cases disregarding the type of tooth movement.

Keywords: CBCT, Cephalometric, Diagnosis, Model, Orthodontics, Planning, Tooth movement, Treatment, Type, X-ray.

The first reported three dimensional diagnosis and orthodontic treatment planning of complex malocclusion with the Invisalign appliance was reported by Boyd and Vlaskalic in 2001 [1]. Although this publication laid out the foundation for Invisalign or clear aligners' diagnosis and treatment planning, continuous development of diagnostic tools like con-beam-computed-tomography (CBCT) for example has enhanced and provided tremendous insights into case diagnosis and treatment planning [2]. Also, the recent introduction of intraoral cameras and scanners that can provide the clinician with immediate digital model, compared to the traditional plaster study casts, can help the clinicians to make immediate informed decision rather than taking long time to work up the cases.

Contemporary orthodontic diagnosis and treatment planning include obtaining of the following records:

Tarek El-Bialy, Donna Galante & Sam Daher

1. Patient's history (Medical and dental)
2. Patient's chief complaint
3. Clinical examination
4. Models (plaster or digital)
5. Radiographic evaluation

PATIENT'S HISTORY (MEDICAL AND DENTAL)

Obtaining patient's history (medical and dental) is of utmost importance. I would like to stress on the following questions to the new or transferred patient:

a. Do you take any medication? If so what medication(s) are you currently taking now? The importance of this question is that, it can discover any underlying systemic illnesses that might affect your decision in terms of treatment planning for the patient. For example, if the patient is under corticosteroid for allergies or asthma, the orthodontist should be aware that corticosteroid affects bone remodeling and consequently orthodontic movement which is tightly linked to duration of treatment. Most new patients will ask the following question (how much time I will be in treatment) and the orthodontist should provide a reasonable answer, without commitment to specific duration. For example, it might be advisable based on the clinician's experience to provide the new patient with a range of treatment time instead of locking himself/herself in specific time by saying (your treatment will take 18 months) it is better to say (cases like your case usually take in my hands 18 months on average depending on how compliant the patient is with my given instructions and also it depends on patients' teeth and bone response to treatment).

b. Dental history is very important to know if the patient had severe dental trauma, root canal treatment, maintaining regular checkup visits with his/her dentist or not. The importance of this information in orthodontic treatment planning includes that in patients that have had trauma to their teeth, tooth mobility and root resorption might be expected. If the patient is maintaining his/her checkup visits to the dentist, this may reflect expected good oral hygiene. Towards the end of this book, I will present a case of bad oral hygiene that led to severe decalcification under the aligners and will discuss

this at the end of this book.

PATIENT'S CHEIF COMPLAINT: Although the orthodontist might see different dental or orthodontic problems in the patient's mouth upon clinical examination or after analyzing the patient's records, it is very important to investigate patients' main concerns and address them during the consultation or during the treatment. Patients with unaddressed concerns might not be happy or the clinician may lose the patients' compliance which can affect the patient's results. In order to explore this chief complaint or concern for the patient, the following question is a traditional one: Why you are here today? Or what brought you up here today?

CLINICAL EXAMINATION: This includes extra oral (profile to check if it is straight, convex or concave), this provides information about whether the patient might have skeletal class I, II or III. Also facial form (brachyfacial, mesofacial or dolichofacial type) to put into consideration the followings: If the patient is brachyfacial type, tooth movement might be difficult due to the fact that brachyfacial type patients usually have strong musculature that normally interferes with changing the occlusal pattern by orthodontic treatment. However, it may be interesting here to say that even with brachyfacial type patients, the use of clear aligners disengage the occlusion by the occlusal coverage of the teeth by plastic that can facilitate tooth movement due to minimized teeth inter-digitation.

On the other hand, dolichocephalic patients might have other problems like open bite. Also, if there is moderate to severe crowding in dolichofacial type cases, it is difficult to expand or distalize molars in these cases as these types of tooth movement can lead to exaggeration of the patient's increased vertical dimension which might result in unacceptable results. It may also be worth mentioning here that in cases of open bite, occlusal coverage of teeth by clear aligners may serve as posterior bite plate that can help with controlling the vertical dimension of the patient.

Clinical examination of the patient's facial symmetry is very important to differentiate between the patients that might require surgical intervention to improve patient's asymmetric face/chin and consequently coordinated

CHAPTER 4

Unique Features of Clear Aligners Compared to Regular Orthodontic Appliances

Abstract: This chapter highlights the important features of clear aligners and their possible added benefit to orthodontic treatment. In particular, clear aligners disarticulate the teeth and this disarticulation makes it easy to achieve inter-arch tooth movement than with regular fixed orthodontic appliances. This chapter presents different features of clear aligners that may make tooth movement easier than fixed orthodontic appliance.

Keywords: Bite clearance, Clear aligners, Disarticulation, Early correction, Fast, Features, Orthodontics, Tooth movement, Unique.

As mentioned earlier in chapter 2 (Science and practice of clear aligners), the type of plastic that has been used to fabricate the clear aligners may have piezoelectric property which, if proven for new plastic materials, can be utilized for faster tooth movement and minimum orthodontically induced root resorption. There are other features that clear aligners may actually provide advantages over regular orthodontic braces. These features, from the author's prospective can be summarized as follows:

1. Clear aligners could be described as a short cut to predictable results compared to trial and errors when using regular braces. In other words, driving around the mountain takes longer time than taking a jet from point A to point B without hassling around the mountains. In other words, the digitally planned estimated end point (results or occlusion) can be predicted using the digital treatment plan (Clincheck for example in the case of Invisalign technology). The clinician can predict and expect how the treatment results would be wheth-

Tarek El-Bialy, Donna Galante & Sam Daher

er the patient is compliant and the patient's biological response to tooth movement is within the normal range.

2. Clear aligners allow the patients to eat sticky or hard food and better oral hygiene compared with traditional fixed orthodontic braces when patients are not allowed to eat any sticky or crunchy foods throughout the treatment otherwise brackets/tubes can be at a high risk of being broken and this would hurdle the treatment progress and might cause gum/check irritation by the broken brackets or displaced orthodontic wires due to the broken brackets. In addition, with regular fixed orthodontic braces, patients have to do meticulous tooth brushing and dental flossing around the wires and brackets/wires to minimize possible enamel decalcifications and/or periodontal disease from accumulated dental plaque around the gingival margins or in the interdental spaces if not cleaned 100%.

3. In cases of noncompliant patients, especially with retainers wear after finishing orthodontic treatment, if relapse occurs, the patient less likely requires new aligners. In the case of using fixed braces, new regular braces might be used. In fact, most likely, relapsed clear aligner cases may be able to re-use their old aligners that can reprogram their treatment towards the initially planned finished occlusions.

4. Clear aligners cover the occlusal surface of the teeth which provides many advantages that can be summarized as follows:

    a. In deep bite cases, with most likely strong musculature, tooth movement is usually restrained or difficult to achieve due to the inclined planes of posterior teeth occlusal cusps. With clear aligners, the occlusal coverage disengages the occlusion that allows for free teeth movement. It can also act as a jaw positioning splint when centric occlusion and centric relationships are not coincident.

    b. In open bite cases, the occlusal coverage of the posterior teeth by clear aligners works as posterior bite plate/block that can help in controlling the vertical dimension, especially when this is combined with anterior vertical

pull chin cup.

c. In cross bite cases, the occlusal coverage of the teeth disengages the occlusion to allow easy movement of the teeth from cross bite to normal bite and this occlusal coverage works as a posterior bite plate that has long been used with removable and fixed orthodontic appliances.

d. Finally, the occlusal coverage of the posterior teeth is very important in class II cases with or without molar distalization as:

i. In cases where molar distalization is required, occlusal coverage of posterior teeth disengages the occlusion and allows for free distal movement of upper posterior teeth.

ii. It helps control vertical dimension and may help intrude posterior teeth, which when occurs can lead to auto-forward rotation of the mandible and consequently helps in class II correction.

5. Clear aligners are more hygienic and less gingival or periodontal problems are encountered with clear aligners when compared to either buccal or lingual fixed orthodontic appliances [1, 2].

6. The improved gingival and periodontal health can also help decrease pain with clear aligners compared to fixed orthodontic treatment [3].

7. Finally, in author's opinion, clear aligners may be used as fluoride application trays should decalcification occur during treatment due to bad oral hygiene.

It should be noted that orthodontic treatment results using clear aligners are mainly dependent on the patient's wear and compliance with the clinician's instructions.

REFERENCES

[1] Schaefer I, Braumann B. Halitosis, oral health and quality of life during treatment with Invisalign(®)

CHAPTER 5

Orthodontic Biomechanics Using Clear Aligners

Abstract: Orthodontic biomechanics is the foundation of orthodontic treatment. It is extremely important to fully understand orthodontic biomechanics before the clinician /orthodontist may utilize specific orthodontic appliance. This chapter highlights basic principles of biomechanics of tooth movement with emphasis on forces, moment, moment to force ratio and its importance in achieving different types of tooth movement. Also, this chapter provides detailed explanation of different types of tooth movement and relativity of moment to force ratio as well as center of rotation approximate location in each type of tooth movement. The application of these concepts with clear aligners is somehow different from the way fixed orthodontic appliance has been used. Explanation of these differences is presented.

Keywords: Aligners, Attachments, Biomechanics, Bodily, Force, Moment, Orthodontics, Ratio, Tipping, Tooth movement, Torque.

FORCE

Force is an act that when applied upon an object can change the object's state from not moving to moving and also can accelerate or decelerate moving object. Force is a vector not a scalar. This means that in order to define a force, it is important to define/describe its magnitude and direction as well as its sense. Direction is described with reference to coordinate system, in other words vertical, horizontal (medio-lateral) or front to back for example. One may call each axis, X, Y or Z for example. Sense is described in terms of right or left (In the horizontal axis), front or back (In the antero-posterior), up or down (In the vertical axis) for example. Forces may be added (if applied in the same direction and sense) or counteract each other (if applied in the same axis but in different senses/directions).

Tarek El-Bialy, Donna Galante & Sam Daher

MOMENT AND THE CONCEPT OF MOMENT TO FORCE RATIO

The concept of moment to force ratio was first introduced by Tanne *et al.*, in 1988 to define different types of tooth movement and changes of center of rotation according to changes of the moment to force ratio [1]. In short, the concept was described as follows. In order to move tooth bodily, a force must be applied to the center of mass or center of resistance of that body. In the case of teeth, the center of resistance is located somewhere in the root(s) and it is not practical to apply forces to the teeth roots.

When a force is applied to the tooth crown, usually it creates a moment (tendency for the tooth to rotate around the center of resistance) as the point of application of the force is away from the center of resistance (usually is located in the tooth root somewhere between the alveolar bone crest and tooth root apex). The produced moment is the resultant of multiplication of the magnitude of the force times the perpendicular distance from the line of action (not the point of application) of the force to the center of resistance (Fig. **5.1**).

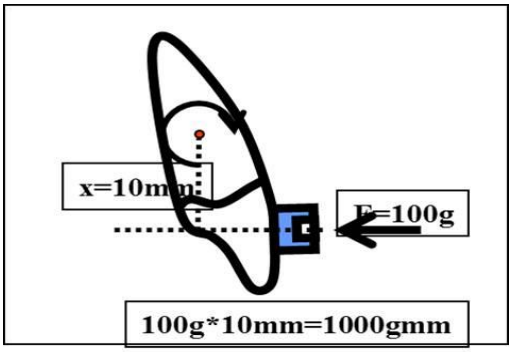


Fig. (5.1). Moment is created when a force is applied to a body (tooth in this example) away from the center of resistance. Moment = Force (100 gm) * perpendicular distance from the force line of action (dashed horizontal line) to the center of resistance (10 mm) = 1000 g mm.

In order to move a tooth bodily without applying forces to the tooth center of resistance directly that is located in the tooth root, it is important to prevent or counter act the initial moment occurred due to the applied force to the teeth crowns. To do so, a counter moment is required to negate the initial moment due to the force. *The ratio between the applied moment and the force is called moment to force ratio* and this

ratio determines the resultant tooth movement (uncontrolled tipping, controlled tipping, bodily or root movement [torque]). These types of tooth movements are explained in detail below. In short, if we assume that the force will move the tooth crown tip in one direction, the counter moment would tend to move the root apex in the same direction or at least prevent the apex from movement in the opposite direction to where the tooth crown is moving.

POSSIBLE ORTHODONTIC TEETH MOVEMENT USING CLEAR ALIGNERS

Initially when clear aligners were introduced, they were introduced to solve minimum crowded teeth (1-2 mm of arch length deficiency); minimum (1-2 mm) dental spacing cases or relapsed cases.

Although many practitioners would argue that simple crowded or spacing cases can be easily corrected using routine removable or fixed orthodontic appliances, challenges as mentioned above with regular fixed appliances are cleaning, diet restriction and bracket positioning errors. Also, regular/tra-ditional removable orthodontic appliances have their own limitations which include bulkiness of the acrylic base, one point contact of the active components (wires/clasps) with the teeth which makes it difficult to control tooth movement or achieving controlled tipping or bodily movement according to the treatment goals.

In this regard, clear aligners may provide better control of tooth movement compared to traditional removable orthodontic appliances and also, when treatment planning is well-designed, difficult tooth movement including but not limited to bodily movement can be achieved.

TYPES OF ORTHODONTIC TOOTH MOVEMENTS

There are four common types of orthodontic tooth movements with regards to crown cusp tip/incisal edge -root apex relationship. There are four common types of tooth movement with regards to general body axes (vertical [intrusion/extr-usion], horizontal [buccal/lingual] and anteroposterior [proclination/retro-clination]) and with regards to the tooth own axis (rotational tooth movement).

CHAPTER 6

Moderate and Severe Crowding Class I Cases

Abstract: Traditional approaches for treating severe crowded cases usually involve removal of some teeth with the intention to allow stable occlusion after the orthodontic treatment. However, in severe constricted cases, arch expansion could be the best approach to treat these cases without removal of permanent teeth. This chapter presents cases with severe teeth crowding and the possible treatment of these cases with clear aligners. This chapter presents moderate to severe crowding cases treated solely by clear aligners utilizing dental arch expansion. Also, this chapter presents diagnostic criteria for deciding expansion/non extraction or extraction approaches in detail.

Keywords: Class I, Expansion, Extraction, Interproximal, Malocclusion, Moderate crowding, Proclination, Severe crowding, Stripping, Spacing.

INTRODUCTION

According to Proffit [1], moderate crowding can be considered when 2-4 mm of dental arch length discrepancy exists [1]. Cases with moderate dental crowding can be treated by different approaches including expansion, proclination in cases with reteroclined upper and /or lower incisors, interproximal reduction (IPR) or extraction in cases with severe skeletal problems like increased vertical dimension/hyperdivergent or open bite cases.

The first report about treatment of moderate crowded cases by Invisalign clear aligners was reported by Boyd, in 2000 [2]. Since then, there have been many reports about the possibility of using Invisalign or clear aligners in general to treat cases with moderate crowded teeth with variable degrees of success and satisfactory finishing [3]. In addition, Boyd has introduced a new protocol for managing complex cases with Invisalign or clear aligners [4]. The following cases with moderate dental crowding were treated solely by Invisalign clear aligners,

Tarek El-Bialy, Donna Galante & Sam Daher

details are as follows.

Case 1

This twelve-year old female presented to the clinic in June 2011 with chief complaint that upper right canine tooth is labially erupted with no room/space in the dental arch to accommodate its normal position (Fig. **6.1**). The patient had relatively normal skeletal relationship, class I molars and canine relationships, upper crowding (4 mm), lower 1.5 mm crowding and upper and lower midlines coincident with facial midline.

Fig. (6.1). Initial photographs of a twelve-year old female with labially erupted upper right canine tooth with upper 4 mm crowding and lower 1.5 mm crowding. Midlines are centered, right and left molars and canines are class I relationship. No Bolton discrepancy existed.

Problem List/Findings

1. Labially erupted upper right canine (4 mm crowding)
2. Slight lingually inclined upper and lower incisors
3. Right side premolars are not fully interdigitated (Slight end to end relationship) can be seen in clincheck (Fig. **6.2**).

Treatment Objectives

1. Resolve upper and lower crowding

2. Maintain midline relationships
3. Maintain left buccal occlusion and improve right occlusion.

Fig. (6.2). Right side premolars are in slight end-to-end relation, and upper right first molar is not fully sucked in (full interdigitation).

Treatment plan included sight expansion (non-extraction) of the upper and lower arches and labial crown torque of upper incisors.

Two treatment options were presented to the patient:

1. Full fixed appliance, or
2. Invisalign clear aligners treatment

Parents and patient were informed with limitations of each technique and both patient and parents chose Invisalign treatment. Patient was fitted with 22 aligners, utilizing class II elastics on both sides to improve buccal occlusion, providing space for upper right canine and left class II elastics were used to prevent canting of anterior occlusal plan. Also, slight proclination of the upper and lower incisors were requested 1) improve their position, and 2) provide space for the buccally erupted upper right canine. (Fig. **6.3**): shows patient after 11 months in treatment

CHAPTER 7

Treatment of Class II Malocclusion Using Clear Aligners

Abstract: Although it has been reported earlier in 2005 that it is difficult to achieve full correction of sagittal relationship (class II or III) either dental or skeletal using clear aligners, pioneer reports by Boyd and Dahr [1, 2] have been stimulating to the creativity of orthodontists who may modify original protocols that were provided by Boyed and Dahr. Proper designing clincheck or treatment planning in class II cases is very important utilizing the principles of both functional appliances and bioprogressive techniques. The following cases will explain how to utilize both functional appliance and bioprogressive principles using clear aligners to correct class II cases. Although, this might seem as case reports or case series, further clinical trials are required to support or otherwise provide other evidences of using clear aligners in correcting class II skeletal and dental cases.

Keywords: Bioprogressive, CBCT, Class II, Clear aligners, Growth modification, Growth prediction, Mechanics, Skeletal, Technique, Treatment planning.

INTRODUCTION

Previous reports have shown that class II cases can be treated by clear aligners [1 - 2]. All available publications in the literature are limited to the use of Invisalign for this type of treatment with no other clear aligners being reported to correct sagittal jaw discrepancy. Different protocols have been reported for class II treatment planning, however the most common ones are: 1) Premolar extraction using 1 mm rectangular attachments for root parallelism using Boyd protocol [1]; 2) Upper arch expansion and upper molar distalization using Dahr protocol where he proposes buccal crown torque (Power Ridge™ feature) on the upper incisors as he starts retraction on the incisors and lingual root torque on the lower incisors [2]. Also, in cases where upper molars distalization is recommended, third molars

Tarek El-Bialy, Donna Galante & Sam Daher

are recommended to be removed to allow for distalization of upper molars. In this case, class II elastics are recommended to be used to support anterior anchorage. According to Dahr [2], if buttons are to be used on the upper canines, it would be better to bond the buttons on the labial surfaces of the upper canines to apply distalization forces closer to the center of rotation.

In my opinion, center of rotation is a function of the tooth movement and it is less predictable to estimate its position, while center of resistance of the tooth is more predictable to locate. Applying the force as cervical as the crown allows, still create moment that tends to tip the canine crown distally and the root mesially by uncontrolled tooth movement. The protocol that has been recommended by Boyed seems to be valid that recommends using vertical square attachments on the canines that can provide couple, this couple can move the canine roots distally along with the crown tips. A detailed explanation of the two views is in the following sketch (Fig. **7.1**).

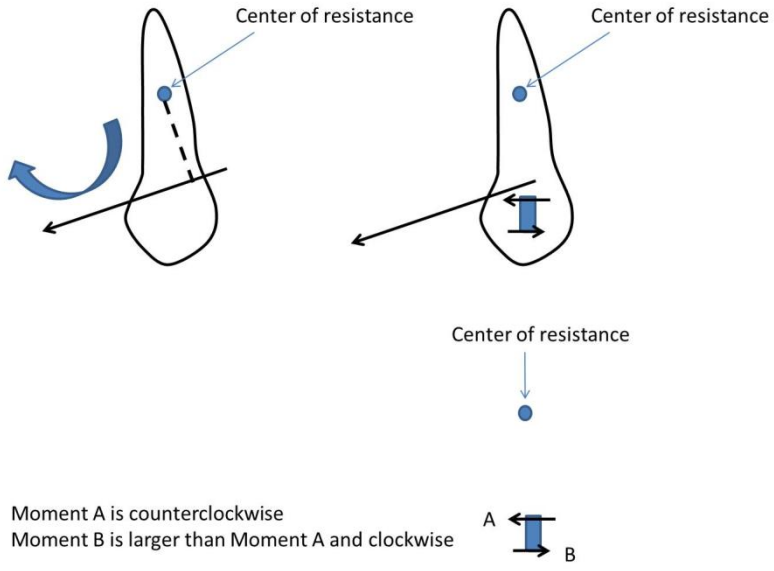


Fig. (7.1). Moment on upper canine without vertical attachment leads to clockwise moment and distal crown tipping of upper canine with most likely uncontrolled tipping of the canine. With vertical attachments (Right figure), a coupe is created with class II elastics that can lead to counter-clockwise moment that automatically upright the canine while retracting with class II elastics or any distal force. Detailed biomechanical analysis of vertical and optimized attachments are underway to provide the best option of either attachments for space closure.

As mentioned before in chapter 6, in order to correct class II malocclusion with proclined upper incisors, if the treatment objectives are to retract upper incisors by bodily movement, palatal root torque (labial crown tip/torque) is required to maintain proper axial inclination of upper incisors.

In his white paper, Dahr 2011 [2] presented an interesting protocol of class II correction with emphasis on using class II elastics and upper molar distalization. This chapter emphasizes on upper and lower incisor torque consideration and possible growth modification using clear aligners.

Previous case reports and publications about treatment of class II solely by Invisalign showed improvement of buccal occlusion, overbite and overjet [1 - 3]. However, most of these reports showed proclination of the lower incisors, in particular when class II elastics were used to distalize upper molars [2, 3], except cases reported by Boyed that showed lower incisor inclination is actually improved after treatment [1]. Exact mechanisms of how lower incisor inclination was improved in Boyed cases were not explicitly explained. In cases where lower incisor inclination are retroclined, it is understandable that class II elastics can procline lower incisors to normal position, however in cases with proclined lower incisors, it is unclear how mechanism(s) were used to retroclined after class II elastics. One can assume that lower crown torque or lower incisor pre-retroclination was requested/performed. This technique looks like the best way of handling class II, especially when class II elastics may be used to distalize upper molars.

Case 1: Class II With Bimaxillary Protrusion

A 19 year-old-female was presented to the clinic with a chief complaint of upper and lower front teeth sticking out that required improvement. Initial records in June 2008 revealed that the patient had a skeletal class II as seen by convex profile with retrognathic mandible and slightly recessive chin (Fig. **7.2**). Regardless of the convex profile, it was accepted by the patient and she did not want to change it. Cephalometric measurements revealed bimaxillary dentoalveolar protrusion and proclination (Fig. **7.3**), (Table **7.1**). Lower incisor inclination was planned to be retroclined (lingual crown torque). Upper incisors

CHAPTER 8

Treatment of Class III Malocclusion Using Clear Aligners

Abstract: Treatment of class III cases with clear aligners maybe a challenge. This is unlike class II where upper molars can be distalized or even do a functional appliance effect. Class III on the other hand, is different. In many growing cases, upper jaw may be required to move forward or restraining lower jaw forward growth in growing children is required. In adult patients, class III management is even more challenging. If a case presented with class III malocclusion that does not have a skeletal component, it can be manageable with clear aligners, however if there is a class III skeletal relationship, orthognathic surgery might be required. Clear aligners still may be used, however careful diagnosis and treatment planning as well as thorough communication with the patients and especially discussion of the treatment expectations is very important before, during and towards finishing of treatment.

Keywords: Camouflage, Class III, Control, Cross-bite, Malocclusion, Mechanics, Occlusal plan, Surgical corrections, Treatment planning, Vertical dimension.

INTRODUCTION

Class III management may include one of the following strategies: 1) only orthodontic management of the dental class III malocclusion would be aimed at camouflage treatment or backward rotation of the mandible which might help improvement of anteroposterior (AP) correction. However backward rotation of the mandible, although can be advantageous in cases with brachy or meso facial types. Backward rotation of the mandible is usually not recommended in cases with high angle or dolichofacial type. 2) Growth modification in growing children might be aimed at maximizing maxillary growth and harnessing, if possible, mandibular growth and 3) Orthognathic surgical treatment, which may involve maxillary forward surgical repositioning or mandibular surgical backward

Tarek El-Bialy, Donna Galante & Sam Daher

setback. In many cases, mandibular surgical backward setback may not be recommended in cases with compromised airway or patients having sleep disorders.

Boyd was the first to publish surgical-orthodontic treatment of two skeletal class III patients with Invisalign and fixed appliances [1]. In his protocol, pre-surgical decompensation of upper and lower incisors, coordination of upper and lower arches are done by Invisalign then a pre-surgical partial bonding with fixed appliance is used for intermaxillary fixation, then post-surgical finishing is done by Invisalign.

The possible use of clear aligners in growing class III cases includes: 1) using clear aligners with cuts for elastics to be hooked to face mask should maxillary protraction is an objective for a patient with maxillary deficiency, 2) camouflage treatment in adults if skeletal imbalance may be acceptable. This may be achieved by intermaxillary class III elastics, or 3) use clear aligners for preparation before surgical intervention to correct the skeletal class III malrelationship.

Case Presentation

This is a 16 years and 6 months old male who presented to our clinic with chief complaint that his front teeth are crowded and he had anterior cross bite. His medical history was non-contributory however his oral hygiene was fair and needed improvement. His profile was slightly convex with a dolichofacial type and slight hypermentalis muscle activity (Fig. **8.1**). Intraoral photographs and digital models (Fig. **8.2**) revealed a class III malocclusion with anterior and posterior cross bites. Also, patient presented with fair oral hygiene that was instructed to improve and visit his dentist for continuous cleanings and checkups. Cephalometric analysis (Table **8.1**) revealed class III skeletal with high mandibular angle. Also, cephalometric analysis revealed slightly protruded and proclined upper incisors while lower incisors were within normal range relative to NB plane, however lower incisors inclination to mandibular plane was reteroclined. These axial inclinations confirm the patient has a class III skeletal relationship as per the apical base discrepancy (ANB, WITS analyses).

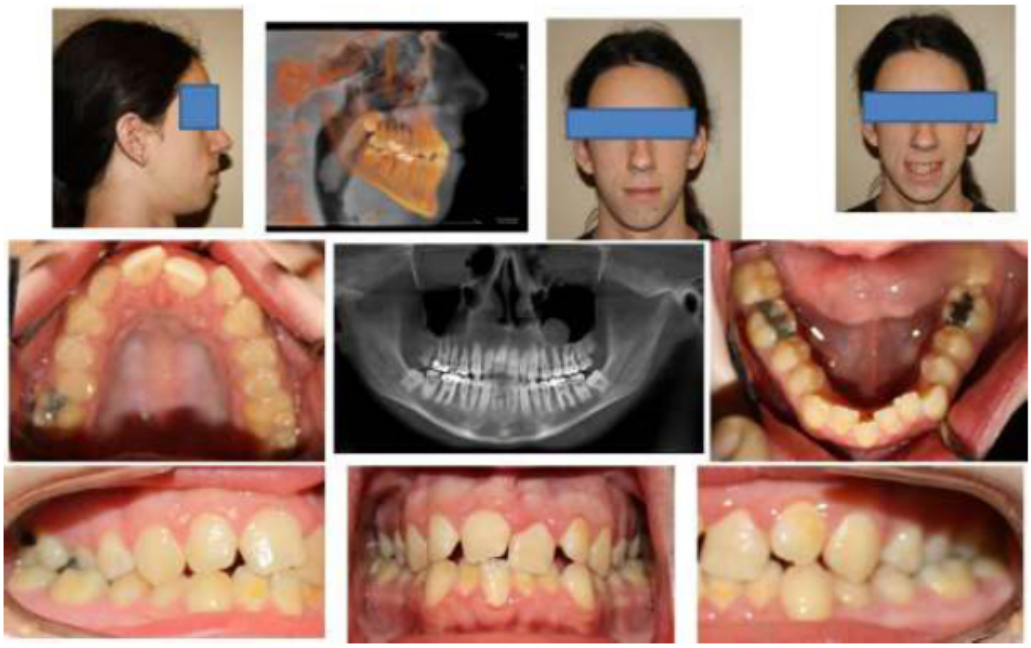


Fig. (8.1). Initial clinical photographs show dolichofacial type and hyper mentalis muscle activity. Also, intraoral photographs reveal class III malocclusion and fair oral hygiene.

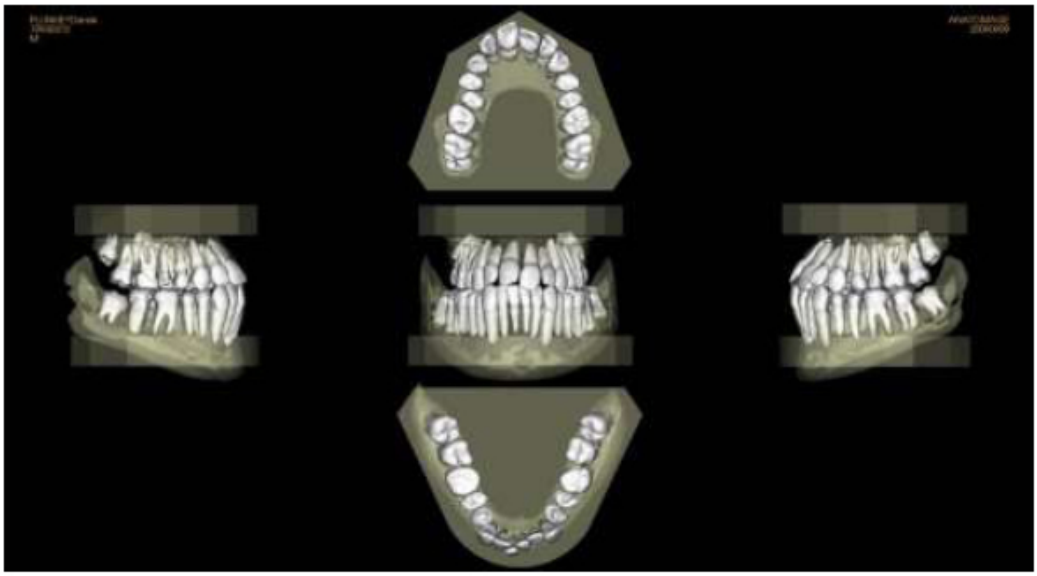


Fig. (8.2). Initial CBCT-generated digital models confirm class III malocclusion and anterior/posterior cross bite.

CHAPTER 9

Treatment of Anterior Open Bite Using Clear Aligner Therapy

Abstract: Anterior open bite can be of dental, skeletal, functional or a combination of all three in origin. An anterior open bite is present when there is no contact between the upper and lower anterior teeth and no overbite (vertical overlap of the upper and lower incisors). The severity of open bite varies from an edge to edge relationship to a severe open bite with teeth contact only in the molar areas. Ideally, treatment of open bites should be started as early as they are diagnosed by the dentist or pediatric dentist/orthodontist. Often, early intervention can eliminate the causes of the open bite especially if they are related to a persistent habit such as thumb sucking or mouth breathing. Also, early intervention can re-direct jaw growth and establish a more favorable mandibular growth direction. This chapter will discuss treatment of open bite in non-growing patients by using clear aligner therapy and no adjunct orthognathic surgery.

Keywords: Anterior open bite, Clear aligners, Control, Edge-to-edge bite, Habit, Intrusion/extrusion, Mouth breathing, Tongue thrusting, Vertical dimension.

INTRODUCTION

Digit sucking is a common cause of anterior open bite. The incidence of digit sucking is around 30% at age 1 and decreases to 2% by age 12 [1]. Open bites that exist in the primary dentition usually will resolve on their own once the child ceases the digit habit. Anterior open bites that extend into the mixed and permanent dentition may require orthodontic or even surgical intervention. A vertical component to growth may occur during this time frame as the child persists with a digit habit, lip or tongue habits, airway obstruction and genetic skeletal growth abnormalities. Complex orthodontic treatment involving the use of molar intrusion with or without temporary anchorage devices may be required.

Tarek El-Bialy, Donna Galante & Sam Daher

Fig. (9.1). Pretreatment clinical records A) photographs showing class III right side and anterior open bite/edge-to edge relationship. B) Initial Cephalometric and panoramic radiographs

Orthognathic surgery is often the last resort in treating these type of cases [2]. Fixed appliance therapy has been the standard of care in orthodontics in correcting

anterior open bites. Unfortunately, research has shown that relapse is frequent with about 40 to 80% relapse [3 - 5]. Persistent anterior tongue position is often cited as one of the most important factors in relapse. Great success has been demonstrated by Dr. Robert Boyd, Chairman of the Department of Orthodontics at the University of Pacific Dental School, with use of clear aligners to treat anterior open bites [6]. This case study will show how clear aligners can predictability close anterior open bite.

CASE 1

A 16 year old female presented to our office with her mother with the chief compliant of a bite problem and not being able to chew properly. Medical history was non-contributory. Her dental history included a previous phase of treatment in the mixed dentition for "several years" while living in Asia. Mom stated that her bite was perfect at the end of that treatment and all her teeth were in place when the braces were removed. Since moving back to the United States, she has grown a few more inches and her bite changed. The patient was not interested in braces or treatment at all, but was more inclined to proceed with Invisalign than fixed appliances. Initial records (Fig. **9.1**) show that the patient has a mesiocephalic face (concave profile and prognathic chin projection) with a midline deviation to the left of approximately 3mm. She has an edge to edge anterior open bite and presents with a Class III molar relationship on the left side. Cephalometric analysis shows a significant class III skeletal pattern, high mandibular plane angle and bimaxillary protrusion of both upper and lower incisors.

Treatment Objectives

A non-extraction approach was presented to the patient and parent. Treatment objectives were to correct the edge-to edge open bite, reduce the bimaxillary protrusion, provide overjet and overbite and align the midlines.

Treatment Plan

Patient did not want to go through fixed orthodontic treatment again and was even reluctant to start Invisalign. However, her mother wanted her to have the bite problem corrected once and for all. She consented to wear clear aligners the

CHAPTER 10

Treatment of Facial Asymmetry Using Clear Aligners

Abstract: There are many etiological factors that could be attributed to facial skeletal asymmetry, including but not limited to hemifacial microsomia, unilateral temporomandibular joint ankylosis especially in growing patients or hypertrophic condyle on one side due to local tumor. Functional facial asymmetry could be attributed to bilateral constricted maxilla and the patient shifts his/her mandible to one side to achieve a comfortable occlusion on one side, or it could be due to dental interference, which mainly occurs due to one tooth in cross bite, usually upper lateral incisor. In this case, treatment is recommended as soon as possible especially in growing subjects to eliminate dental interference or to expand the maxilla so that no possible remodeling can happen in both TMJ fossae and possible need for surgical intervention later in life to fix jaw asymmetry. This chapter will discuss in details careful diagnosis of a case with facial asymmetry to simplify treatment planning.

Keywords: CBCT, Chin deviation, Crossbite, Elastics, Facial symmetry, Functional shift, Root movement, Stability, Tipping, Tomogrms.

INTRODUCTION

Lateral mandibular functional shift in the mixed dentition has been recommended to be treated as early as possible to eliminate possible permanent changes in the TMJ and fossa [1 - 9]. It has been reported that in growing children with lateral functional shift due to bilateral maxillary constriction or due to dental interference, treatment of unilateral cross bite can lead to self-correction of the lateral shift and this treatment and correction of condylar position in the glenoid fossa that may minimizing the need for orthognathic surgical correction in the future [4, 7, 8]. Tomograms confirm abnormal condylar position in both sides in cases with functional mandibular shift [4, 7, 8]. Another study showed that

Tarek El-Bialy, Donna Galante & Sam Daher

unilateral posterior crossbite can lead to asymmetric mandibular ramus height [6]. This study however is questionable as they used panoramic radiograph in assessing ramal height. Panoramic radiographs are known to have measurement errors due to the inherited magnification errors. Tomograms seem to be the best method of confirming mandibular condylar position before and after treatment.

Treatment of unilateral posterior crossbite may be performed using palatal expansion appliances (either removable or fixed), full fixed appliances with coordinated upper and lower archwires and/or crossbite elastics [10]. This chapter will show that functional mandibular shift once diagnosed and confirmed, can be treated as simple as removable appliance may be used to treat similar cases.

CASE PRESENTATION

This is a 39 years old female who presented to our clinic with a chief complaint that her dentist is referring her for comprehensive orthodontic treatment and surgical correction of her facial asymmetry. History revealed that the patient had no medical concern and she was initially interested in Invisalign treatment as fixed orthodontic braces were too challenging for her. However, her dentist who is an Invisalign provider convinced her that she is not a candidate for Invisalign treatment due to the high likelihood of surgical intervention and she better have comprehensive orthodontic treatment by an orthodontist and jaw surgery by an oral and maxillofacial surgeon. Clinical records (Fig. **10.1**) revealed that the patient had a balanced face with chin deviated to the patient's right side. Intraoral photographs show that the patient has cross bite of upper right lateral incisor and right buccal segment. Usually, cases with unilateral posterior cross bites develop facial asymmetry especially when the unilateral cross bite leads to lateral mandibular shift. In growing children, it is believed that fixing unilateral cross bite would lead to self-correction of the lateral shift and the possibility of minimizing the potential for the need of surgical intervention when the patient grows up beyond adulthood.

To confirm if the patient had skeletal asymmetry or functional shift, tomograms would be required. The advantage of CBCT is that tomograms are simply generated. Evaluation of the patient's initial CBCT generated tomograms

(Fig. **10.2**) confirmed the functional shift.

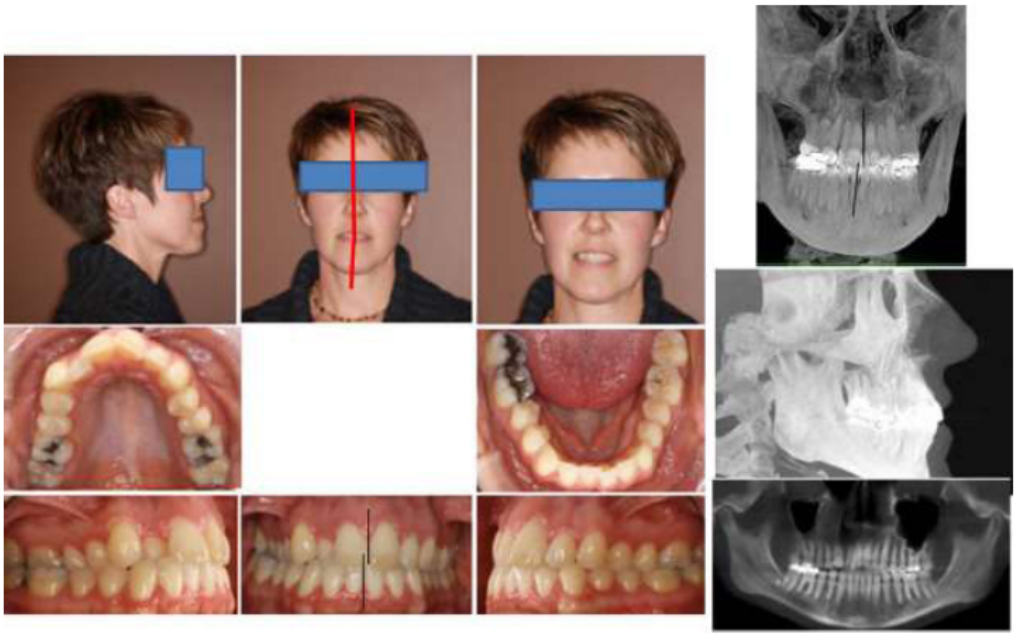


Fig. (10.1). Initial clinical records of the patient with facial asymmetry. CBCT generated frontal cephalometric radiograph showing shift of the chin to the patient's right side.

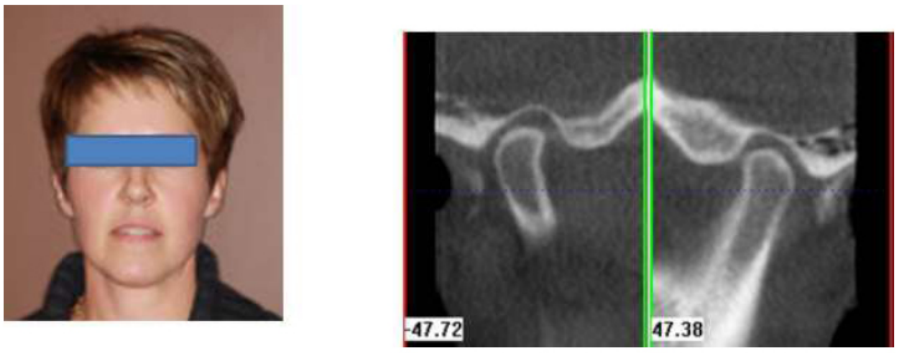


Fig. (10.2). Initial tomograms showing functional shift as the right side condyle of the patient has a posterior shift, while left condyle showing forward shift. The shifts are confirmed by comparing anterior and posterior disk spaces on each side.

Lateral cephalometric analysis showed a balanced cephalometric values (Table **10.1**) while frontal cephalometric analysis showed chin deviation to the patient's right side. CBCT sagittal screen shows lingual tipping of the crowns as posterior

CHAPTER 11

Treatment of Challenging Cases Using Clear Aligners

Abstract: Limitations of using clear aligners include noncompliance and compromised/fair oral hygiene. Rotational tooth movement also could be a challenge. Small thin teeth are also hard to move. The following chapter will discuss these limitations and possible strategies to manage these limitations.

Keywords: Case selection, Challenging tooth movement, Clear aligners, Compliance, Decalcification, Limitations, Outcomes, Relapse, Retention, Prognosis.

In a paper published in 2007, clinical limitations of clear aligners, especially Invisalign were presented [1]. In this paper, the authors outlined some malocclusions that he outlined as not candidates for clear aligners treatment. These conditions are 1) crowding and spacing over 5 mm; 2) skeletal anterior-posterior discrepancies of more than 2 mm (as measured by discrepancies in cuspid relationships); 3) centric-relation and centric-occlusion discrepancies; 4) severely rotated teeth (more than 20 degrees); 5) open bites (anterior and posterior) that need to be closed; 6) extrusion of teeth; 7) severely tipped teeth (more than 45 degrees); 8) teeth with short clinical crowns; and 9) arches with multiple missing teeth. Although these conditions might have been difficult to treat in 2007 not all of them are not candidates for clear aligners.

You can see in this book that some difficult cases like severe apical base discrepancies (skeletal Class II and class III) are treated successfully in this book. Also, severely tipped teeth (Case 4 in class II chapter) is treated within a year. Also, cases with centric-relation and centric-occlusion discrepancies can be treat-

Tarek El-Bialy, Donna Galante & Sam Daher

ed now with clear aligners (Facial asymmetric, Chapter 10 of this book). Although, there are no open bite cases presented in this book but there have been many reports in the literature about effective treatment of open bite cases with clear aligners [2 - 7].

In recent presentation at Invisalign Summit for orthodontists in November 2012, it was declared to all attendees that any orthodontic case can be treated by clear aligners. In this book chapter, two cases are presented highlighting the limitations of clear aligners.

Fig. (11.1). The top above intraoral photos revealed fair oral hygiene starting in June 2011. Progress photos (bottom raw) show severe hypo-mineralization after a one year treatment and hypertrophic gingival growth.

Case 1

This twelve-year old male presented in June 2011 with a chief complain that he had moderate to minimum crowded upper and lower teeth that required them to be treated. The patient presented initially with fair oral hygiene that was instructed to improve during the course of treatment. After one year of Invisalign wear, the patient developed a severe hypocalcification (Fig. **11.1**). The dentist was in a position to stop the treatment until remineralization occurs. After discussion with

the patient, parents and the dentist, the patient continued to wear the clear aligners and was instructed to us the clear aligners as fluoride. Clinical follow up revealed partial remineralization however not fully recovered.

This could be attributed to the fact that clear aligners may be working as microbial/plaque incubator if the patient does not maintain excellent oral hygiene. Part of this problem is that some patients cannot clean the aligners from inside as they are supposed to. Clear instructions to the patients to make sure that they should keep the aligners clear that the patients can see through them. If the aligners start to be cloudy, it is not advisable to use them until the patient cleans them thoroughly.

Case 2

This is a 45-year-old female who presented to the orthodontic clinic with a complaint of relapsed crowded teeth after initial orthodontic treatment. She had minimum upper and lower minimum dental crowding (Fig. **11.2**). Patient was given different treatment options including clear braces metal braces and she requested clear aligners. After consultation and discussing the pros and cons of each technique, the patient was insistent to have clear aligners for her treatment.

Fig. (11.2). Initial records of the 45-year old female.

CHAPTER 12

Surgical Orthodontics Treatment with Invisalign

Abstract: Surgical orthodontic treatment is usually required in cases having severe skeletal mal-relationships and malocclusion that cannot be resolved solely by orthodontic treatment. In managing surgical orthodontic cases, pre-surgical orthodontic treatment usually aims at coordinating both dental arches, eliminating dental compensation due to the skeletal mal-relationship if present and to eliminate any dental interferences once dental arches are occluding together after the skeletal mal-relationship is corrected by surgical intervention. Post-surgical orthodontic treatment usually aims at finishing and detailing dental arch relationships and ensure that no interferences exist. Traditionally, pre-surgical and post-surgical orthodontic treatments are usually achieved by regular fixed orthodontic appliances and pre-surgical orthodontics usually require having the patients wearing heavy archwires in order to be used for inter-maxillary fixation after surgery. The introduction of clear aligners in surgical orthodontics was initially somehow not well-received by orthodontists and oral surgeons due to the fact that rigid archwires are needed before surgery and clear aligners may have limitations on what can be done in terms of preparing cases with skeletal mal-relationships for orthognathic surgeries. The present chapter will shed the light on surgical orthodontic cases that were treated solely by clear aligners before and after orthognathic surgeries as well as describe steps in management of such cases using clear aligners.

Keywords: Clear aligners, Decompensation, Diagnosis, Orthodontics, Post-surgical, Pre-surgical, Stability, Surgical orthodontics, Temporary anchorage devices, Treatment planning.

INTRODUCTION

Surgical orthodontic correction of dentofacial deformities including jaw mal-relationship aims to improve facial aesthetic and function in these cases [1]. A successful outcome of orthognathic surgery depends on the planning and execut-

Tarek El-Bialy, Donna Galante & Sam Daher

ion of orthodontic and surgical techniques [2 - 5]. Surgical orthodontic planning involves model surgery, traditional cephalometric prediction as well as photographic prediction or utilization of computerized cephalometric/photographic predictions [6, 7]. Model surgical prediction suffers from potential errors including model mounting of jaw relationship by face bow/bite transfer. In complex cases, dental compensation and crowding may necessitate extraction of teeth. In class II skeletal cases when extraction is required for decompensation and relieving crowding is needed, the extraction pattern usually involves lower first premolars and upper second premolars. The reverse pattern is usually the case in severe skeletal class III. However, in many cases where dental compensation is not too severe, or when crowding is not moderate or severe, extraction may not be necessary for pre-surgical orthodontics phase. Many cases can be treated pre-surgically by arch development (expansion) and incisors torque as well as interproximal reduction.

Align technology uses a digital diagnostic set up, using Clincheck® software, that allows the clinician to plan and predict tooth alignment, dental arch relationships, as well as viewing dental occlusion from different aspects that are normally hard to see or evaluate using plaster models. In addition, it helps clinicians with planning the treatment as well as mitigating dental interferences before they occur.

Case 1

This is a 27 year-old female that was presented with a chief complaint that she had overbite and a small chin. Clinical examination and clinical records (Figs. **12.1** & **12.2**) revealed the following findings:

1. Convex profile with recessive chin and relatively large nose and increased nasolabial angle.
2. Class II skeletal and dental relationships due to mandibular retrognathism
3. ANB angle = 6.6°
4. Overjet = 8 mm and overbite is 80%
5. Increased curve of Spee
6. Minimum crowding of the upper arch that was narrow (tapered) and no

crowding in the lower dental arch.

7. Wisdom teeth were missing and no major dental anomalies.

Fig. (12.1). Initial clinical records of patient #1. Extraoral photos show patient had a convex profile due to recessive chin and relatively large nose. Class II division 1 malocclusion with increased curve of Spee.

Fig. (12.2). Initial radiographs showing skeletal Class II relation.

Future Directions with Clear Aligners

Future direction of clear aligners could be directed at setting up protocols that can be used in complex malocclusion cases, especially for extraction and rotation of small teeth. Materials with more stable shape memory might be introduced that are capable of producing computer animated or planned tooth movement in real situation. The implementation of CBCT in diagnosis and communication with technicians is very important. However, this would entail proper knowledge of clear aligner companies' technician to be more aware of CBCT, limitations of tooth movement and early communication with clear aligners' prescribers. Again, utilization of TADs together with clear aligners can provide an alternative treatment to difficult cases that are currently not considered candidates for clear aligners.

Tarek El-Bialy, Donna Galante & Sam Daher

SUBJECT INDEX

Tarek El-Bialy

Dr. Tarek El-Bialy is a professor of Orthodontics and Bioengineering at the University of Alberta. Dr. El-Bialy has published over 70 peer reviewed publications, two books and 11 book chapters. He presented all over the world more than 150 times. He has extensive research in orthodontic biomechanics and enhancing tooth movement as well as treatment of difficult cases with clear aligners. Dr. El-Bialy philosophy of treatment is to minimize extraction of teeth as possible and treat complex cases without surgery whenever possible.