Abstract
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Educational Objectives
Upon completion of this course, the reader should be able to:
1. Be familiar with the components of the clear aligner system;
2. Understand that clear aligners are capable of treating a broad spectrum of malocclusion; and
3. Appreciate the complexities of mastering orthodontic treatment with clear aligners.

Author Profile
ClearCorrect™ Clinical Advisor, Ken Fischer, DDS received his orthodontic certificate from UCLA in 1975 and has maintained his private practice of orthodontics in Villa Park, California. Dr. Fischer was an early adopter of clear aligner treatment in 2000 and has treated nearly 1,500 patients with clear aligners. He has shared his treatment experiences with both domestic and international audiences, published a number of articles regarding clear aligners, and has also served as a clinical advisor for Invisalign™.

Author Disclosure
Ken Fischer, DDS, is a clinical advisor for the sponsor of the unrestricted educational grant for this course.

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Abstract/Introduction
Since its inception, the methodology of using clear aligners [Figure 1] or trays as a means of sequentially straightening teeth has evolved significantly to where, today, the technique has been adopted by many dentists wanting to provide some degree of orthodontic correction for their patients. Once limited to correcting small amounts of crowding or spaces in fully erupted dentitions, it is now utilized by experienced clinicians in a broad spectrum of the comprehensive treatment of complex malocclusions. This course will trace that evolution and document the validity of using clear aligners in contemporary orthodontic treatment.

In the Beginning
Without question, in addition to cost and discomfort, esthetics are a major factor when patients consider straightening their teeth with braces. Advances in adhesives and metallurgy have made orthodontic treatment with metal and ceramic braces somewhat more attractive, but many patients still resist having braces attached to their teeth. The concept of clear, removable aligners to straighten teeth has offered reluctant patients an alternative to the traditional braces they did not want to wear.

In the 1940s, Dr. H. D. Kesling developed a process in which he removed the teeth from stone models, reset them in wax back on the original models in an ideal alignment [Figure 2], and fabricated a rubber mouthguard-type of mold for the patient’s upper and lower teeth to fit into, called a “positioner” [Figure 3]. With adequate wear, the patient’s teeth would move into the ideal alignment designed on the reset models. Later, in 1959, Dr. Henry Nahoum built upon Dr. Kesling’s concept of resetting teeth by developing a process for vacuum forming a piece of clear plastic to tightly encase the teeth on a stone model. Dr. Nahoum used his mother’s WILFA vacuum cleaner to create a vacuum in a 55-gallon drum. He connected a butterfly gate valve to the top of the drum and set an inverted coffee can onto the gate valve. Next, he placed a stone model of the teeth covered by a thin piece of plastic on the perforated bottom. After heating the plastic with his mother’s flat iron to just the right temperature, he opened the gate valve and the vacuum created in the drum pulled the plastic down over the stone model, forming a tightly fitting clear tray to encase the teeth. Here is how Dr. Nahoum described his process:

“The appliance may also be fabricated to move teeth. Anterior spaces can be closed and minor rotations can be corrected. To do this, a plaster cast is made. The teeth are sawed off the cast with a jeweler’s saw or a fissure bur. The teeth are then repositioned on the model with wax. The contour appliance is vacuum formed over the altered (waxed) model. The excess is cut away with a razor and the appliance is removed from the cast, cleaned and inserted into the mouth.”


In 1997, two graduate students founded a company which introduced clear aligners to the mass market, revolutionizing the way doctors considered esthetics in orthodontic treatment. Their business model incorporated mass production, digital computer imaging, unconventional marketing directly to the public, and a new paradigm that challenged doctors’ training and experience. During the early 2000s, dentists were introduced to a technique defined by mass-customization, digital computer imaging, unconventional marketing directly to the public, and a new paradigm that challenged their training and experience. Wanting to step slowly into this new treatment modality with unproven results, clinicians were advised to utilize clear aligners only for patients with small amounts of crowding or spaces in dentitions with second permanent molars fully erupted. With increasing experience, doctors impatient with these “advised” restrictions began expanding the scope of “what is possible” with the new appliance, and are now treating patients presenting with moderate to severe crowding, deep bites, constricted arches, and other complex corrections, even four bicuspid extraction cases.

Modern clear aligner therapy requires:
• specially engineered software for strategically relocating teeth on the digital models in a sequential order;
• plastic material uniquely formulated for optimum aligner performance;
• a rich set of features to aid the aligners in moving teeth (i.e., the animated setups, optional additions of composite to enhance function of the aligners, measurement and analytical tools, and the utilization of auxiliary devices) and,
• most importantly, the doctor’s level of training and experience in tooth movement, orthodontic treatment principles, and utilization of clear aligners.

There’s More Involved Than Just Clear Trays

The Software
At the core of the ability for aligners to be effectively used for orthodontic corrections lies digital 3-D dental imaging and a software program® designed to rearrange the teeth on the digital models in a manner that allows the teeth to be straightened in a sequential order from “crooked” to “straight” [Figure 5]. The software is manipulated by a technician, or the doctor in some cases, to design a treatment plan according to the doctor’s provided prescription. The parameters and velocity of the tooth movements are uniquely calculated for each tooth depending upon the crown shape, root size, and position in the arch. These metrics, designed for each sequential step, or stage, are engineered into the software, but may be over-ridden, within reasonable limits, by the doctor’s directions.

The software will display the digital treatment plan in both static and animated modes [Figure 6]. There are a variety of features included in the software to enhance the reviewer’s analysis of the proposed plan, including: multi-axis rotation of the digital model, measurement tools, tooth size/space analysis, etc.

After a critical review of the animated treatment plan, the doctor can approve the plan to initiate the aligner fabrication, provide instructions to the technician to revise the proposed plan, or decline the plan and withdraw the submission of the case without further obligation.

The animated treatment plan can be shared with colleagues, family, and friends via the internet on smartphones, laptops, and remote desktops, serving as an excellent communication tool.
The Plastic Material
The choice of which plastic material to use for a series of aligners is made by the manufacturer, not the doctor ordering them. Each aligner provider has their own reasons for choosing which plastic product they will use based upon the combination of characteristics and properties they want to promote. The plastic’s clarity, durability, stain resistance, rigidity, flexibility, and use of single or multiple layers during thermoforming are all properties that contribute to the definition of a manufacturer’s aligners’ characteristics. The reality is that there is not a plastic product rated superior for all of these properties, so doctors must decide which characteristics they value most when selecting the provider for their aligners.

Studies\(^4\)\(^,\)\(^5\) have shown that when used to deliver tooth-movement forces, thermoplastic materials exhibit stress relief, or “creep”. This occurs for the duration of their use, adversely affecting the mechanical properties. This phenomenon is the result of the plastic’s inherent elasticity and will vary from one material to another. Some providers desire a stiffer, less elastic material that will reduce the aligner creep, while others prefer a multilayer material that gives the patient a softer, more comfortable fit.\(^5\)

The “Buttons”
The software technicians frequently suggest the placement of small dollops of tooth-colored composite material on certain teeth which will be encased in a tiny “bubble” in the aligners [Figure 7]. Whether they are called “engagers,” “attachments,” or “buttons,” these are simply small amounts of composite material bonded to the facial or lingual surface of the tooth. The number, various shapes, and location placements are determined by the software technician and approved or modified by the doctor. While widely believed to significantly improve the efficacy of tooth movement, there are no published reports that verify this belief, or that one shape is more effective than another. However, there are published reports\(^6\) supporting the claim that the most valid usage of these items is for increasing the retention of the aligner. Until more credible research is published, the actual effectiveness of these common additions to the aligner system must remain theoretical.

Elastics used for class II or class III traction can be attached to buttons bonded to the facial surface of cusps and molars [Figure 8], or, as an alternative technique, attached to slits cut out of the aligner margin next to the cusps and molars [Figure 9]. When the elastic is attached to a button bonded on the tooth, the full force of the elastic is transmitted to the tooth and related alveolar structure. If the elastic is connected to the aligner in some manner, the full force of the elastic is dissipated throughout the full arch via the aligners, minimizing the desired effect of the elastic traction. Those clinicians preferring the attachment of the elastic onto the aligner feel it saves them chair time to have the manufacturer provide the elastic cutouts. Without knowing exactly when to start or stop the application of the elastics, the patient must accept the presence of the slits in all their aligner stages, unless there is a midcourse correction made without the slits. These clinicians must closely observe for any aligner deformation or displacement caused by the elastic forces; even a small displacement of the aligner material away from the facial surface of the cuspid reduces the aligner effect on that tooth. If the elastic force is too heavy, the whole aligner can be pulled down off the teeth.

Clinicians who prefer to attach the elastic to a button on the tooth believe the chair time required to initially bond and remove the buttons and modify the aligners during the elastic wear is minimal and offset by the increased effectiveness of the technique, i.e., shorter time required for the patient to wear the elastic.

Although not always highly predictable,\(^7\) aligners can accomplish about 3-4 mm of dental arch expansion. If skeletal expansion is advised, some type of appliance should be used to accomplish adequate skeletal expansion prior to taking the impressions or scans for the aligners. A transpalatal appliance of some design is inserted to hold the achieved expansion until the delivery of the first aligners. An aligner with full palatal coverage may be used as a trial aligner to get the patient used to wearing the removable device. Expanding the underlying skeletal foundation increases the stability of the dental expansion and other movements created by the aligners.

Figure 7. Engagers
![Engagers](image)

Figure 8. Elastics with buttons
![Elastics with buttons](image)
The Dental Profession’s Acceptance

Every day, advances in technology affect the way we live and work. Indeed, advances in clear aligner technology have changed orthodontics forever … but not without some controversy.

Originally offered only to orthodontic specialists, this revolutionary technology now provides diagnostic assistance, a prediction of the designed treatment result, and a prefabricated appliance to achieve the projected goal to any licensed dentist. While most orthodontists were reluctant to embrace the new method for straightening teeth without braces attached to the teeth, general dentists without orthodontic training or education recognized the clear aligners as a pathway to expanding the scope of care they could offer to their patients.

Today, the dental profession as a whole promotes the popular concept of “cosmetic dentistry” with the use of clear aligners, however, often overlooking the long-standing standards for an optimal or ideal occlusion as it is defined during extended training and education.9

The evidence supporting the clinical effectiveness of orthodontic treatment and predictability14 continues to build. Once thought to be beyond the control of clear aligners, molar distalization and extraction space closure are no longer doubted to be within the scope of achievable successful treatment.10,11,12

Periodontists are also singing the praises of treating periodontally threatened patients with clear aligners due to the controlled delivery of forces and the patient’s ability to better respond to periodontal treatment that can often run concurrent with the ongoing orthodontic treatment.13

The Public’s Awareness and Demand

The mass marketing of clear aligners to consumers via TV, social media, publications, and other media has motivated patients to seek orthodontic correction they never would have considered if fixed braces were their only option. Clear aligners often offer the consumer the option to improve their smile by only straightening their upper front teeth. It is the dentist’s responsibility to explain all of the reasonable treatment alternatives to the patient, but the patient should have the final say in making the treatment decision. Studies14 have shown that the public’s satisfaction with clear aligners to correct their malocclusion is growing and driving dentists to gain proficiency in this novel treatment modality.

From Easy to Difficult, It’s All Possible

Regardless of the brand of aligners chosen or the level of experience treating with fixed braces, one new to treatment with clear aligners is well advised to choose “easy” cases as their first. This category will include minor crowding or spaces, minimal rotations (less than 5°), and exclude skeletal imbalances, anterior-posterior discrepancies, extrusions, extractions, and short or very small teeth. These cases will usually require five or six (or fewer) sets of aligners (set = one upper and one lower aligner) [Figures 10 and 11].

“Moderate” cases represent the typical classification for the practitioner looking to expand their clinical experience with clear aligners. Moderate crowding and spaces, need for dental expansion (as contrasted to skeletal expansion), deep bites, single lower anterior extraction, and midline alignment are examples of typical corrections that can be made with this level of treatment. These cases will use seven to twelve sets (or fewer) of aligners [Figures 12 and 13].

Only the dentists who are sufficiently experienced with clear aligner treatment, trained in the diagnosis of orthodontic malocclusions, and knowledgeable of tooth movement principles should attempt to correct the “difficult” cases. Multiple extractions, presurgery alignment, severe crowding or deep bite, and skeletal imbalances should all be considered difficult to correct with clear aligners.

This degree of experience is not only helpful in creating a good digital treatment plan, but it is absolutely necessary for the proper monitoring and treatment management demanded by these harder cases [Figures 14 and 15].
Clear aligners for correcting complex orthodontic problems have been available to dentists for nearly two decades, with their acceptance and utilization growing significantly every year. However, many still do not appreciate or understand the complexities involved in using clear trays to sequentially move teeth in comprehensive orthodontic corrections, allowing them to scan teeth, request a digital setup of the treatment plan, dispense the aligners to the patient, and expect the treatment result forecasted in the setup. With the proper education, training, and experience, clinicians can expect to achieve optimum treatment results in a broad spectrum of malocclusions with clear aligners.

References
Questions

1. In the early days of using a sequential series of clear aligners to straighten teeth, the technique was limited to:
   a. Limited amounts of crowding
   b. Small spaces
   c. Dentitions with fully-erupted second molars
   d. All of the above

2. Today, clear aligners are not recommended for treatment of:
   a. A broad spectrum of complex malocclusions
   b. Deciduous dentitions
   c. Extraction cases
   d. Presurgery dental alignment

3. In the 1940s, the technique of resetting teeth on a model for the fabrication of an appliance to straighten those teeth was developed by:
   a. Robert M. Ricketts
   b. Ron M. Roncone
   c. H. D. Kesling
   d. Edward H. Angle

4. The appliance referenced above is known as a:
   a. Herbst
   b. Frankel
   c. Positioner
   d. Bionator

5. The first person to create a process for vacuum-forming a clear plastic tray over teeth was:
   a. Henry Ford
   b. Thomas Edison
   c. Isaac Singer
   d. Henry Nahoum

6. The vacuum used to suck the plastic down over the dental model was created by:
   a. The inventor’s mother’s vacuum cleaner
   b. The inventor sucking vigorously on a long tube
   c. A bellows operated by the inventor’s son
   d. A miniature water pump

7. The cofounders who introduced clear aligners to the mass market were:
   a. Public activists at Berkley
   b. Graduate students
   c. In their sixth year at a junior college
   d. UCLA cheerleaders

8. The new technique of clear aligners introduced to dentists in the early 2000s was innovating with:
   a. Mass-customization
   b. Digital computer imaging
   c. Unconventional marketing directly to the public
   d. All of the above

9. Which of the following is not a key component of the clear aligner system?
   a. Special engineered software
   b. Uniquely formulated plastic material
   c. A rich set of features for aiding the treatment setup design
   d. A complex and complicated screening process for selecting qualified patients

10. Modern clear aligner therapy requires:
    a. Orthodontic treatment principles and techniques
    b. Plastic uniquely formulated for optimum aligner performance
    c. Specially engineered software.
    d. All of the above.

11. The core of the aligners’ ability to effectively make orthodontic corrections is:
    a. The number of attachments it requires.
    b. The company from which the doctor buys the aligners
    c. 3D dental imaging and a software program engineered to sequentially reposition teeth
    d. The treatment documentation that is shipped with each set of aligners

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ClearCorrect™ clinical advisor Ken Fischer, DDS, received his orthodontic certificate from UCLA in 1975 and has maintained his private practice of orthodontics in Villa Park, California, since that time. He was an early adopter of clear aligner treatment in 2000 and has treated nearly 1,500 patients with clear aligners. He has shared his treatment experiences with both domestic and international audiences, published a number of articles regarding clear aligners, and has also served as a clinical advisor for Invisalign™.

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12. Which of the following would the doctor not use as a determinate of the tooth’s velocity during movement?
   a. Crown shape
   b. Root size
   c. Age of the patient
   d. Tooth’s location in the arch

13. After a doctor reviews a technician’s recommended treatment plan via the setup, which of the following is not one of his/her options?
   a. Decline the plan and terminate the treatment
   b. Revise the plan and request another setup
   c. Approve the plan and begin fabrication of the aligners
   d. Request that the proposed plan be transferred to another doctor

14. The least desirable property characteristic of aligner material is:
   a. Clarity
   b. Roughness
   c. Strength
   d. Stain resistance

15. The stress relief exhibited by all aligner plastic materials is known as:
   a. Creep
   b. Crawl
   c. Scoot
   d. Relaxation

16. The small dollops of composite material bonded on the tooth are known as:
   a. Engagers
   b. Attachments
   c. Buttons
   d. All of the above

17. The primary effectiveness of a button is to improve:
   a. Tooth movements
   b. Aligner retention
   c. Movement velocity
   d. Patient compliance

18. Which of the following is not a true statement regarding engagers?
   a. They must be used in every case
   b. The doctor must ultimately approve or modify each one
   c. There is no research to validate that one shape is more effective than another
   d. There is no research to validate that engagers significantly improve tooth movement.

19. Which of the following is not considered as an auxiliary in clear aligner treatment?
   a. Expanders
   b. TADs
   c. Elastics
   d. Retainers

20. Elastics can be utilized with clear aligners by wearing them:
   a. From buttons bonded directly to the teeth
   b. From slits cut into the gingival margin of the aligners
   c. From TADs placed in the gingiva above the aligner margin
   d. All of the above

21. The clinicians preferring to attach elastics directly to the slits in the aligner believe:
   a. This technique will provide the best possible treatment result
   b. This technique does not require the patient’s compliance
   c. This technique saves the doctor chair time
   d. This technique is proven to be the most effective way to use elastics

22. Most clinicians believe the dental arch can be expanded with clear aligners:
   a. Not at all
   b. 1-2 mm
   c. 3-4 mm
   d. 5 mm or more

23. Using clear aligners to straighten teeth has changed orthodontics forever due to:
   a. Clear plastic materials
   b. Technology
   c. Clinicians’ acceptance
   d. Trained technicians

24. The prescription of clear aligners for comprehensive orthodontic treatment is available to:
   a. Dental hygienists
   b. Lab technicians
   c. Any licensed dentist
   d. All of the above

25. The public’s awareness of clear aligners has been heightened by:
   a. Mass marketing directly to the public
   b. Low treatment fees
   c. Short treatment times
   d. Radio ads

26. The public’s satisfaction and demand for clear aligners is:
   a. Nonexistent
   b. Decreasing
   c. Unchanged
   d. Growing

27. A clinician new to clear aligner treatment should begin their experience with:
   a. Easy cases
   b. Moderate cases
   c. Difficult cases
   d. Aligners combined with traditional braces

28. Easy cases are characterized by:
   a. Skeletal imbalances
   b. Extractions
   c. Minor crowding or spaces
   d. Anterior-posterior discrepancies

29. Moderate cases include:
   a. 1-5 sets of aligners
   b. 6-12 sets of aligners
   c. An unlimited number of aligners
   d. None of the above

30. In order to treat difficult cases, a doctor does not need to be knowledgeable or proficient in:
   a. Tooth movement principles
   b. Diagnosis and treatment planning
   c. Proper monitoring and treatment management
   d. Placing TADs
**Orthodontic Treatment with Clear Aligners**

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**Course Evaluation**

1. Were the individual course objectives met?
   - Objective #1: Yes  No
   - Objective #2: Yes  No
   - Objective #3: Yes  No

   Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

   2. To what extent were the course objectives accomplished overall?  5  4  3  2  1  0
   3. Please rate your personal mastery of the course objectives.  5  4  3  2  1  0
   4. How would you rate the objectives and educational methods?  5  4  3  2  1  0

   5. How do you rate the author’s grasp of the topic?  5  4  3  2  1  0
   6. Please rate the instructor’s effectiveness.  5  4  3  2  1  0
   7. Was the overall administration of the course effective?  5  4  3  2  1  0
   8. Please rate the usefulness and clinical applicability of this course.  5  4  3  2  1  0
   9. Please rate the usefulness of the supplemental weblogaphy.  5  4  3  2  1  0
   10. Do you feel that the references were adequate?  Yes  No
   11. Would you participate in a similar program on a different topic?  Yes  No
   12. If any of the continuing education questions were unclear or ambiguous, please list them.
   13. Were there any subject matter you found confusing? Please describe.
   14. How long did it take you to complete this course?

   15. What additional continuing dental education topics would you like to see?

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