Journal of the World Federation of Orthodontists 11 (2022) 216–225

Contents lists available at ScienceDirect

Journal of the World Federation of Orthodontists

journal homepage: www.ejwf.org

Customized adjuncts with clear aligner therapy: "The Golden Circle Model" explained!

Nikhilesh R. Vaid[a,*], Waddah Sabouni[b], Benedict Wilmes[c], Yashodhan M. Bichu[d], Digant P. Thakkar[e], Samar M. Adel[f]

[a] Adjunct Professor, Department of Orthodontics, Saveetha Dental College & Hospital, Saveetha Institute of Medical and Technical Sciences, Chennai, India
[b] Private Practice, Invisalign Center, Dubai, United Arab Emirates
[c] Professor, Department of Orthodontics, University of Dusseldorf, Dusseldorf, Germany
[d] International Center for Dental Excellence, Abu Dhabi, United Arab Emirates
[e] PhD Fellow, Department of Orthodontics, Manav Rachna Dental College, Haryana, India
[f] Lecturer, Department of Orthodontics, Faculty of Dentistry, Alexandria University, Alexandria, Egypt

ARTICLE INFO

Article history:
Received 5 October 2022
Accepted 13 October 2022
Available online 15 November 2022

Keywords:
Biomechanics
Clear aligner therapy
Creative adjuncts
Golden circle model
Invisalign
Limitations

ABSTRACT

Clear aligners are the most debated infusion of technology into the orthodontic stratosphere and currently account for a sizable chunk of the orthodontic commercial market. Data indicate that a series of plastic aligners alone cannot resolve all the variants of malocclusion routinely treated by our specialty. Current literary consensus exists that the discrepancy between the predicted and actual clinical outcomes with clear aligner therapy (CAT) is around 50% or more, necessitating midcourse corrections, refinement, or additional aligners, or even a conversion to fixed appliances before the end of treatment. A practical panacea to improve the predictability of CAT is the addition of creative and customized adjuncts to CAT. This article, inspired by the "Golden Circle Model", addresses questions such as the "WHY, HOW, and WHAT" of adjuncts used in combination with CAT and depicts an "inside out" approach (from WHY to WHAT) to present the rationale, stepwise clinical workflow, and the advantages of these adjuncts. The bootstrap, mini pin-supported mesialization or distalization, Yin-Yang attachments, Beneslider, Mesialslider, BMX Expander, and Computer-Aided Design (CAD) / Computer-Aided-Manufacturing (CAM)–based innovative appliance designs among others, are presented as adjuncts to CAT in this article. These adjuncts can either be used concomitantly with the aligners or planned as a separate phase of treatment before the commencement of the actual CAT, based on the type of tooth movement required and whether the planned tooth movement is indicated for a single tooth or a group of teeth. An astute clinician who wishes to expand the repertoire of malocclusions that can be successfully managed by CAT should judiciously plan the inclusion of such adjunct appliances in their aligner treatment planning.

1. "Can pieces of plastic move teeth predictably?"

Aligners are the most debated infusion of technology into the orthodontic stratosphere and currently account for a sizable chunk of the orthodontic commercial market. What started as an alternative appliance two decades ago has today emerged as a comprehensive treatment solution. If we were to "delink the commercial advertising and the marketing chutzpah" around aligner therapy and focus on the science alone, it has undoubtedly been a journey that will leave "an indelible mark on the pages of the orthodontic history" [1–4].

Data from millions of patients in the past few decades are a testimony to the fact that a series of plastic aligners alone cannot resolve all the variants of malocclusion routinely treated by our specialty, irrespective of the advances in the software design, modeling, clinician expertise, or the type of clear aligner material developed. Strong diagnostic acumen, solid biomechanical understanding of different types of orthodontic tooth movements, an astute knowledge of the limitations of clear aligner therapy (CAT),

Funding: The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests: Authors have completed and submitted the ICMJE Form for Disclosure of potential conflicts of interest. None declared.

Provenance and peer review: Commissioned; Internally peer reviewed.

* Corresponding author: Adjunct Professor, Department of Orthodontics, Saveetha Dental College & Hospital, Saveetha Institute of Medical and Technical Sciences, Chennai, India

E-mail address: orthonik@gmail.com (N.R. Vaid).

2212-4438/$ – see front matter © 2022 World Federation of Orthodontists. Published by Elsevier Inc. All rights reserved.
https://doi.org/10.1016/j.ejwf.2022.10.005

and finally, the ever-evolving ability of the clinician to continually innovate as per various clinical scenarios, all play a significant role in attaining treatment efficacy as well as efficiency [5,6].

A plethora of concepts, methods, and auxiliary techniques (including composite attachments); interproximal reduction; dynamic aligner change; power ridges to optimize forces; and auxiliary anchorage devices (e.g., brackets, buttons, mini-screws [or similar temporary skeletal anchorage devices]), combined with the use of intraoral elastics, have all been used and subsequently reported in scholarly literature [7–12]. This article dwells on these techniques through the "Golden Circle Model", the need for these techniques, and technology-aided solutions that render CAT more personalized and predictable.

2. 'The Golden Circle Model

Simon Sinek, a British-American author, and marketing consultant is credited with the development of the "Golden Circle Model" (Fig. 1) that consists of the questions "WHY, HOW, and WHAT". According to Sinek, most professionals know "WHAT" they are doing, some also know "HOW" they do it, and very few know "WHY" they are doing it. "WHY" implies the purpose of doing things, and the author states that unsuccessful professionals think from the "outside in" (from WHAT to WHY), whereas the more inspiring stories think from the "inside out" (from WHY to WHAT) [13].

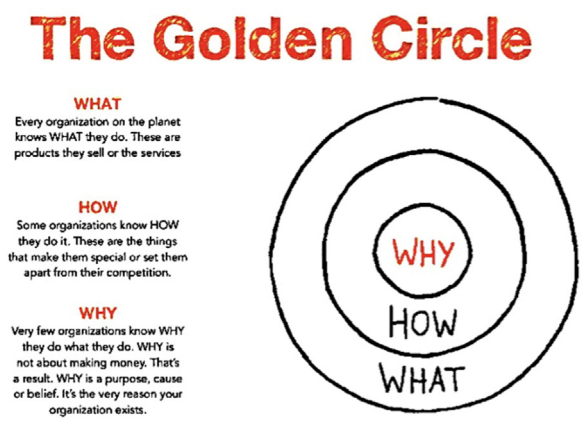


Fig. 1. "The Golden Circle" model as described by Simon Sinek outlining an "inside out" (from WHY to WHAT) philosophy.

3. "WHY" do we need adjuncts for CAT?

Clinical deployment of CAT as a treatment modality has increased exponentially and continues its upward spiral [3,4]. CAT is one of the most robust applications of digital technology, where tooth movement is programmed to a simulation. When teeth are assigned a target position, virtual planning, tracking, and quantifying their movements through treatment becomes integral to therapeutic success [14]. However, discussions regarding the accuracy and efficacy of CAT continue to raise questions and remain a pertinent point of deliberation in contemporary literature [5,15]. Limitations in treating complex malocclusions, for which a consistent mismatch between the predicted and actual clinical outcomes, specifically in terms of the amount and the type of tooth movement, have been reported [10,16]. Over the years, a substantial body of research has focused exclusively on the efficacy of tooth movement with CAT. Current literary consensus exists that the discrepancy between the predicted and actual clinical outcomes is around ≥50%, necessitating multiple stages of refinements or additional treatment [10,17]. Similarly, literature has also reported that 70% to 80% of patients treated with CAT require midcourse correction, refinement, or additional aligners or they might even need a conversion to fixed appliances before the end of treatment [17].

Upadhyay and Arqub [5] have presented the efficiency of aligners (in %) for different types of orthodontic tooth movement graphically to depict the consensus from the available literature on how good aligners actually are at moving teeth (Fig. 2). They have stated

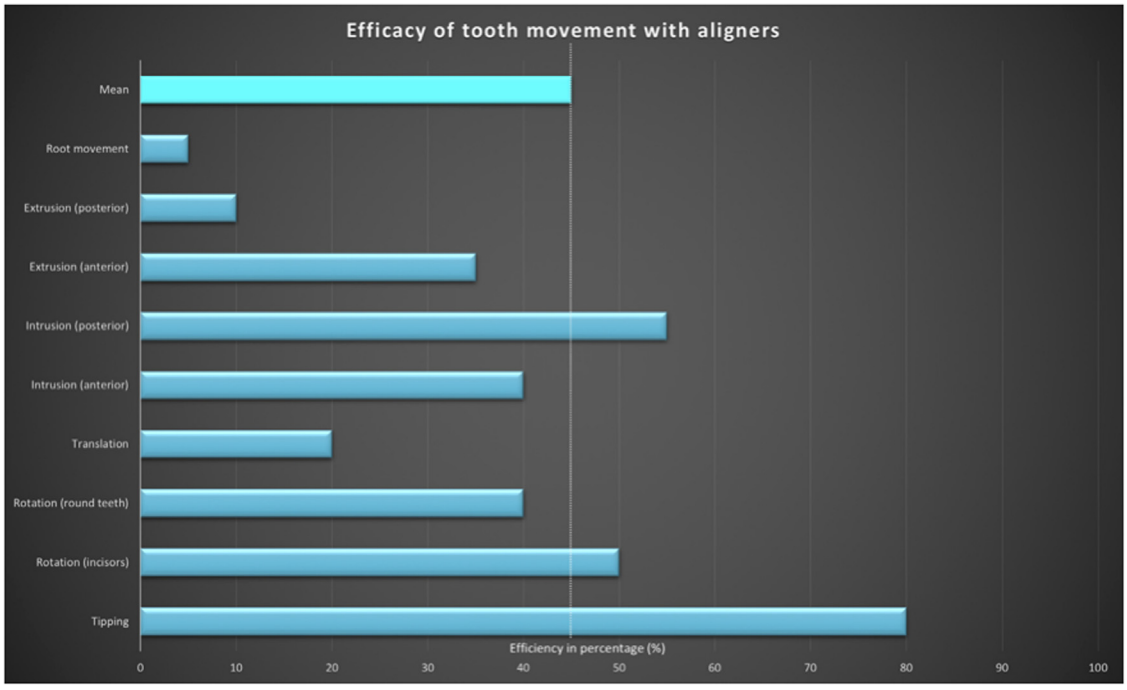


Fig. 2. Aligner efficiency for different types of tooth movement (from Upadhyay and Arqub) [5].

tipping to be the most predictable tooth movement, whereas root movement or torquing was considered to be the least predictable movement, with recent literature demonstrating the mean efficiency of aligners to be 50%.

Achieving orthodontic tooth movement with CAT is more complex than it is with fixed appliances, and this can be attributed to the absence of specific points of force application, variations in tooth anatomy, properties of aligner materials, a mismatch between aligner and dentition geometries, slipping motions between contact shapes, and other biomechanical factors [18]. Accurate treatment prediction has long been a challenge for orthodontists, as well as for the plethora of prediction algorithms used by multiple commercial aligner manufacturers. A practical solution to improve predictability and optimize treatment duration is the addition of a predictable and customized adjunct to clear aligners that can also serve to reduce the need for multiple refinements.

4. Classification of adjuncts to aligners

Commonly used adjuncts to CAT can be broadly categorized based on the type of tooth movement indicated and whether the planned tooth movement is indicated for a single tooth or a group of teeth.

The categories and applications outlined in this article have been elucidated in Table 1.

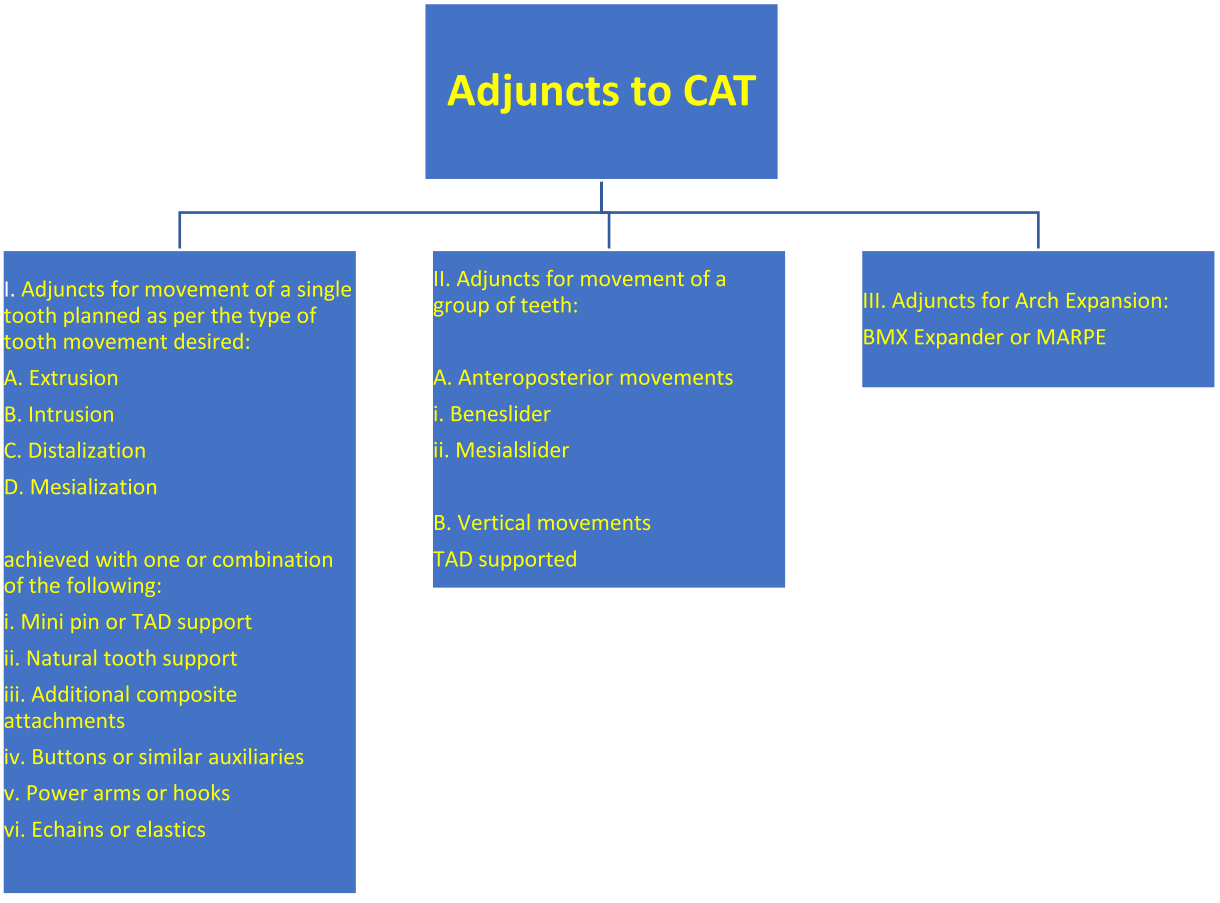
4.1. Adjuncts for single-tooth movement

A single tooth that does not track as planned and demonstrates lag of tooth movement is a common occurrence during the course of aligner progression, and these movements could be in the form of extrusion, intrusion, mesialization, or distalization. Planning a midcourse refinement or correction to order new sets of aligners not only increases overall treatment duration but also seems cumbersome just for a single tooth. Creative adjuncts can be planned either before or during CAT, based on one's clinical expertise to improve the single-tooth tracking and minimize the need for refinements.

4.1.1. Adjunct for single-tooth extrusion (bootstrap)

Aligners are intrusive appliances by nature [19] and as a consequence, extrusion of teeth seldom tracks as planned, especially for maxillary lateral incisors or round teeth, such as premolars. When the tooth movement for such teeth does not track as planned, or the extrusion for a single tooth demonstrates perceptible lag, instead of planning refinements, the simple use of elastics to pull the tooth down into the aligner space can be accomplished using a method known as the "bootstrap" [20], depicted in Fig. 3A and 3B. Akin to a foot entering into a shoe, this adjunct ensures that the tooth in question can be pulled into the aligner space, and the further course of aligners can be continued from there on as planned,

Table 1
The categorization of commonly utilized adjuncts to CAT based on the type of tooth movement indicated and whether the planned tooth movement is indicated for a single tooth or a group of teeth



CAT, clear aligner therapy; MARPE, mini-implant-assisted rapid palatal expansion techniques; TAD, temporary anchorage device.

Fig. 3. Illustrating the use of the "bootstrap" as an adjunct to CAT for single-tooth extrusion. (A) Elastic cut-outs on lingual side. (B) Elastic engaged above aligner to the bonded button on the buccal side.

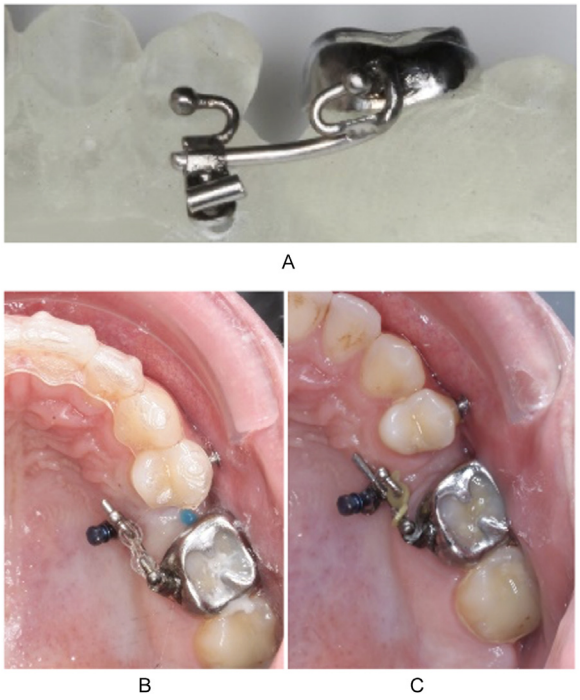


Fig. 4. (A–C) Illustrate mini pin-supported single-tooth mesialization for the upper arch as an adjunct to CAT. (A) Mini pin-supported molar mesializer. (B) Aligner segmented distal to first premolar for independent mesialization of the first molar. (C) Intraoral view of the mesializer without the aligner in place.

especially for maxillary lateral incisors that are frequently smaller in size and/or knife edge in cross-section and fail to extrude even after large sized attachments on them. In such scenarios, 100% extrusion of the tooth can be planned initially, digitally using the bootstrap in the first aligner itself. Once the desired amount of extrusion is achieved, further course of aligners for remaining alignment can be continued as planned, thereby simplifying treatments with CAT and making the overall treatment more predictable.

4.1.2. Adjunct for single-tooth mesialization—mini pin-supported

First molars are multirooted entities and are frequently difficult to mesialize, either with aligners or with conventional fixed appliances. To simplify the clinical outcome of mesialization of molars, an assembly of the molar band with a sliding arm and hook, connected with a sliding tube and hook in the opposite direction, supported by an inter-radicular mini pin can be used. Elastic chains are then used to mesialize the molars, and aligners are sectioned or not fabricated distal to the terminal premolar to assist the mesialization. This adjunct is typically used when only a single tooth is to be mesialized and is commonly indicated in the case of missing premolar, where the first molar is to be mesialized to finish treatment with a dental Class II molar relation (Fig. 4A–4C illustrate mini pin-supported single-tooth mesialization for the upper arch as an adjunct to CAT and Fig. 5A–5C illustrate the same for the lower arch).

4.1.3. Adjunct for single-tooth mesialization—tooth supported

Similar to the mini pin-supported mesialization appliance, instead of obtaining anchorage from a mini pin, open bands are fabricated by metal casting or selective laser melting on the buccal, the palatal, or the lingual side of the tooth, based on required biomechanics, along with a tube on the anchor teeth and a sliding arm on the tooth to be mesialized. Hooks on the tube and sliding arm are then used to engage elastic chains, and the tooth to be mesialized is excluded from the aligner. The presence of an aligner on the remaining teeth acts as a consolidated anchorage unit, thereby facilitating the mesialization of the molar. Once the desired mesialization is achieved, if any further finishing or settling correction is needed in the mesialized segment, a refinement scan can be made to obtain additional aligners (Fig. 6A–6C depict tooth-supported single-tooth mesialization as an adjunct to CAT).

4.1.4. Adjunct for single-tooth mesialization—Yin-Yang attachments

The G6 protocol of Invisalign clear aligners (Align Tech, CA) allows only 2 mm mesialization of molars, and the G6 protocol cannot be applied if any molar movement of more than 2 mm is indicated in a particular clinical situation. An orthodontist can then rely on the knowledge of biomechanics and plan tooth movements similar to manual wire manipulation during fixed orthodontics, albeit digitally on a computer using the Clincheck Pro software and the use of creative attachment, such as the Yin-Yang attachments [21]. This is a twin attachment placed on the buccal side of mesializing molar (Fig. 7) to impart forces necessary to accentuate the mesial root tip, and over corrections are then planned in the Clincheck.

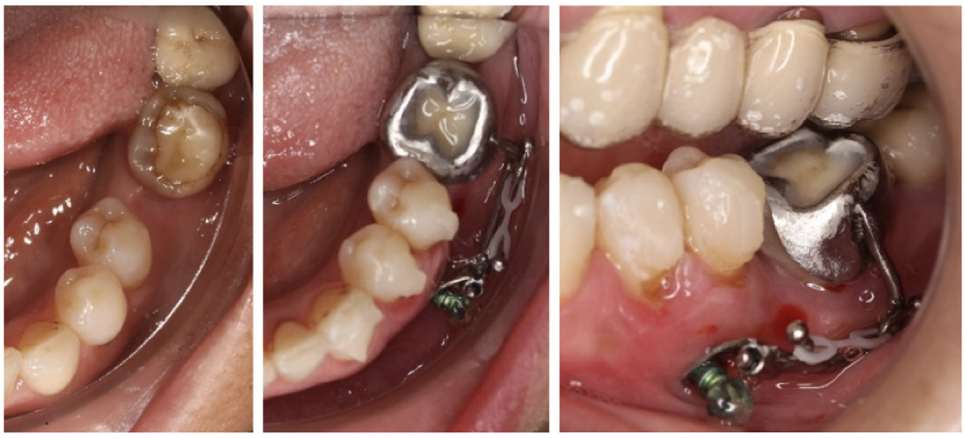


Fig. 5. (A–C) Illustrate mini pin-supported single-tooth mesialization for the lower arch as an adjunct to CAT. (A) Missing or extracted lower first molar. (B) Occlusal view of pin-supported mesializer. (C) Buccal view of the mesializer.

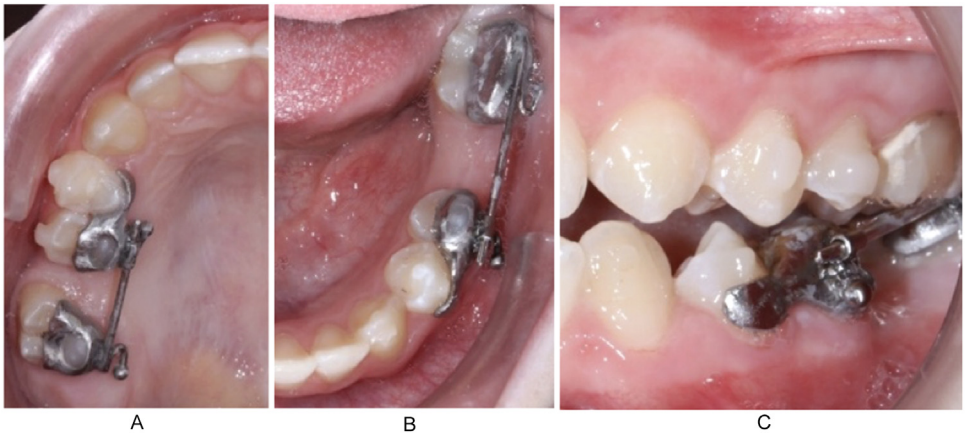


Fig. 6. (A–C) Depict tooth-supported single-tooth mesialization as an adjunct to CAT.

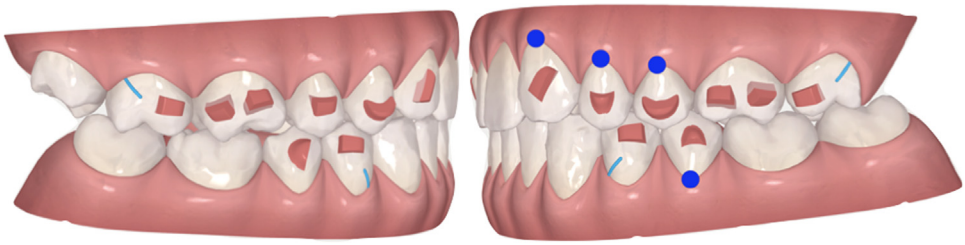


Fig. 7. Yin-Yang attachments on first molars, left and right buccal views.

4.1.5. Adjunct for single-tooth distalization—temporary anchorage device (TAD)-supported and power arm assembly

Missing lower first molars in clinical situations of lower anterior crowding provides an opportunity for the relief of anterior crowding by the distalization of canines and premolars. This distalization can be simplified by the incorporation of TADs and the inclusion of a power arm on the tooth to be distalized for biomechanical efficiency and the use of an elastic chain to distalize a single tooth during treatment with CAT, as depicted in Fig. 8. Once adequate distalization of the tooth next to the extraction space is obtained, the power arm can be again recreated on the subsequent mesial tooth to continue predictable distalization, with change of elastic chain from the TAD assembly.

Fig. 8. The incorporation of a power arm for single-tooth distalization with an elastic chain from a TAD assembly as an adjunct to CAT.

Fig. 9. (A–D) The use of the Beneslider appliance with a coil spring and mobilizer. (A) Beneslider with a coil spring activated to distalize first molar. (B) First molar distalized and space created for erupting and highly placed canines. (C) Distalized molars stabilized as an anchor by removing the elastic coil springs and providing a mesial stop using mobilizer.

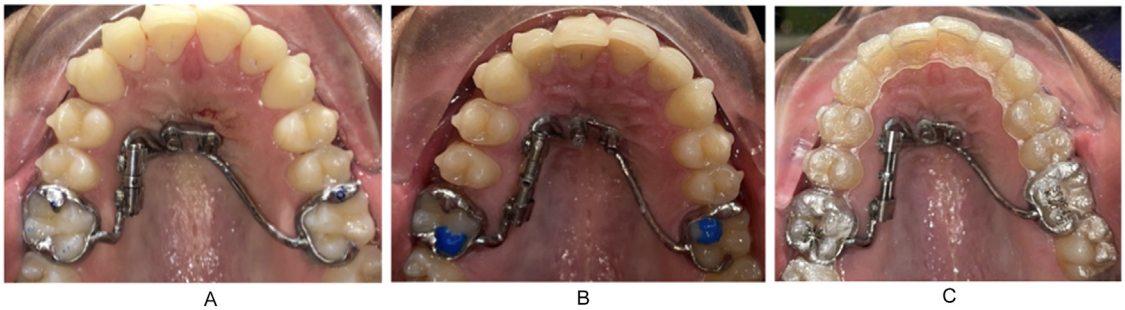


Fig. 10. Illustrates the Distalizer appliance combined with a Slim Line HYRAX appliance to distalize the first molars as an adjunct to CAT. (A) Distalizer with Slim Line HYRAX appliance to distalize the first molars. (B) First molar distalized and needful space created. (C) Aligners fitted with Distalizer in place.

4.2. Adjuncts for movement of group of teeth

Certain clinical situations may necessitate the need to distalize or mesialize a whole segment of the dentition to attain the final desired canine and molar relation or to close the space of congenitally missing teeth, such as the maxillary lateral incisors, and eventually substitute them with the canines. These movements, when accomplished only with aligners, require digital planning, where individual tooth movement is staged, also known as “sou moto” staging [22]. This pattern of tooth movement increases the number of aligners significantly and demands considerable patient adherence to wearing elastics to reinforce the anchorage. To make such treatments more predictable, with reduced patient adherence, the following types of adjuncts can be considered.

4.2.1. Adjuncts for anteroposterior movement of a group of teeth

1. Beneslider: The Beneslider appliance is supported by palatal mini pins and comprises multiple parts, such as a rectangular rail, mini-implants with fixation screws, molar bands or shell, with or without buccal tube, Versalock triple tube, Mobilizer, and a super elastic coil spring or Slim Line HYRAX [23,24]. Multiple teeth can be distalized with a super elastic coil spring or by opening the HYRAX screw. Once the desired distalization of the molars is achieved, some spacing may be noted mesial to the molars and the aligners are then used to close these spaces, during which the mini pin-supported palatal assembly attached to the distalized segment acts as the anchorage unit. This simplifies the distalization process, reduces the overall treatment duration and the number of aligners required, and improves the availability of anchorage. The super elastic coil spring is activated by the distal repositioning of the mobilizer incrementally over a period to control the force application. In case a HYRAX screw is used, the HYRAX screw is opened once weekly to achieve a 0.2 mm activation. Fig. 9 depicts the use of the Beneslider appliance with a coil spring and mobilizer, and Fig. 10 illustrates the Distalizer appliance combined with a Slim Line HYRAX appliance to distalize the first molars as an adjunct to CAT.
2. Mesialslider: Similar to the Beneslider, the Mesialslider appliance (Fig. 11) can be used in situations that demand mesialization or protraction of teeth, such as in the case of missing maxillary lateral incisors, where lateral incisor substitution by the canines is indicated or for finishing with a Class II molar relation in case of missing maxillary second premolar [25,26].

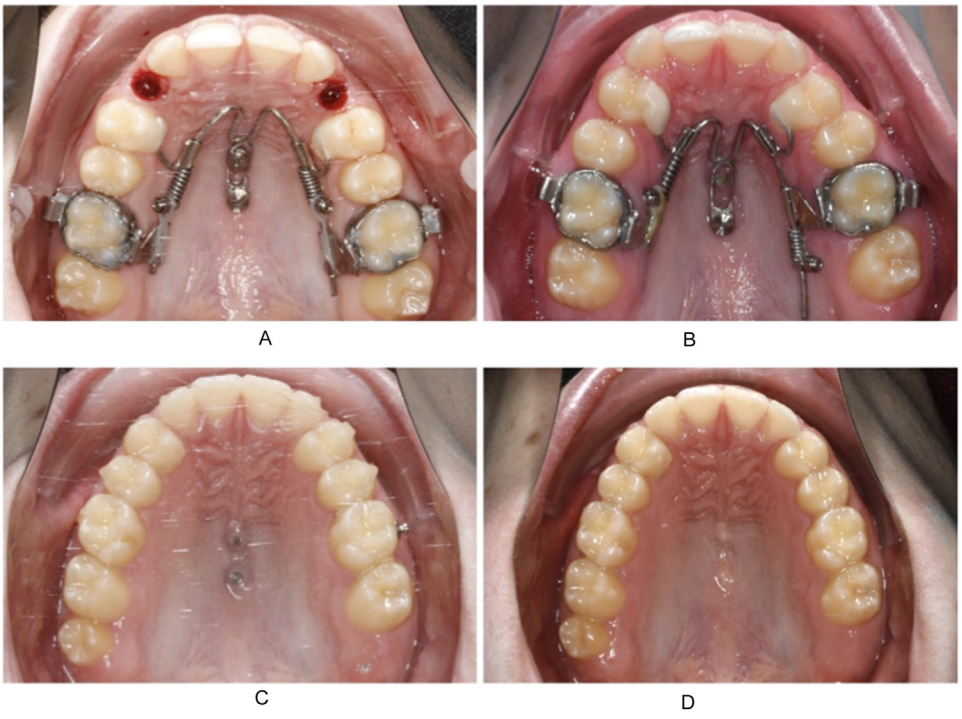


Fig. 11. (A–D) Depict the use of a Mesialslider for the mesialization of maxillary premolars to close the spaces of missing canines.

Fig. 12. (A, B) The use of W intrusion assembly for the desired intrusion of multiple maxillary posterior teeth in combination with CAT (Kind courtesy Dr. Waddah Sabouni).

This appliance can be designed in three different manners and comprises parts and a workflow similar to Beneslider, with the exception that with the activation of the open-coil spring, the mobilizer is completed in a reverse direction, creating a force for mesialization. Multiple teeth bilaterally can be mesialized before the start of treatment with clear aligners. Once the desired mesialization is achieved, aligners can be used for attaining a desired arch form, finishing and/or settling of the occlusion as needed. This appliance prevents the need for large number of aligners and minimizes mesial tipping of the molars during the planned mesial movement, apart from providing predictable tooth movement. Fig. 11A to 11D depict the use of a Mesialslider for the mesialization of maxillary premolars to close the spaces of missing canines.

4.2.2. Adjuncts for vertical movement of a group of teeth

The unabated extrusion of posterior teeth of one arch because of the long-standing loss and subsequent nonreplacement of teeth in the opposing arch is a commonly encountered but a challenging preprosthetic clinical situation in adult orthodontics. Single-tooth intrusion can be predictably obtained with a single mini screw; however, the intrusion of multiple posterior teeth may demand stronger anchorage units and innovative designs. The W intrusion assembly, using a combination of TADs, along with CAT, is an adjunct that can help attain the desired intrusion (Fig. 12). Advances in Computer-Aided Design (CAD) / Computer-Aided Manufacture (CAM) have now enabled clinicians to design and print customized appliances that can further improve the biomechanical execution of desired intrusion of a group of teeth, [27] as demonstrated in Fig. 13.

4.3. Adjuncts for Arch Expansion

4.3.1. BMX Expander and mini-implant–assisted rapid palatal expansion techniques

Maxillary transverse deficiency is a commonly encountered malocclusion and is often associated with a unilateral or bilateral skeletal crossbite. Such cases of skeletal crossbite may require more than just dental expansion for proper settling of

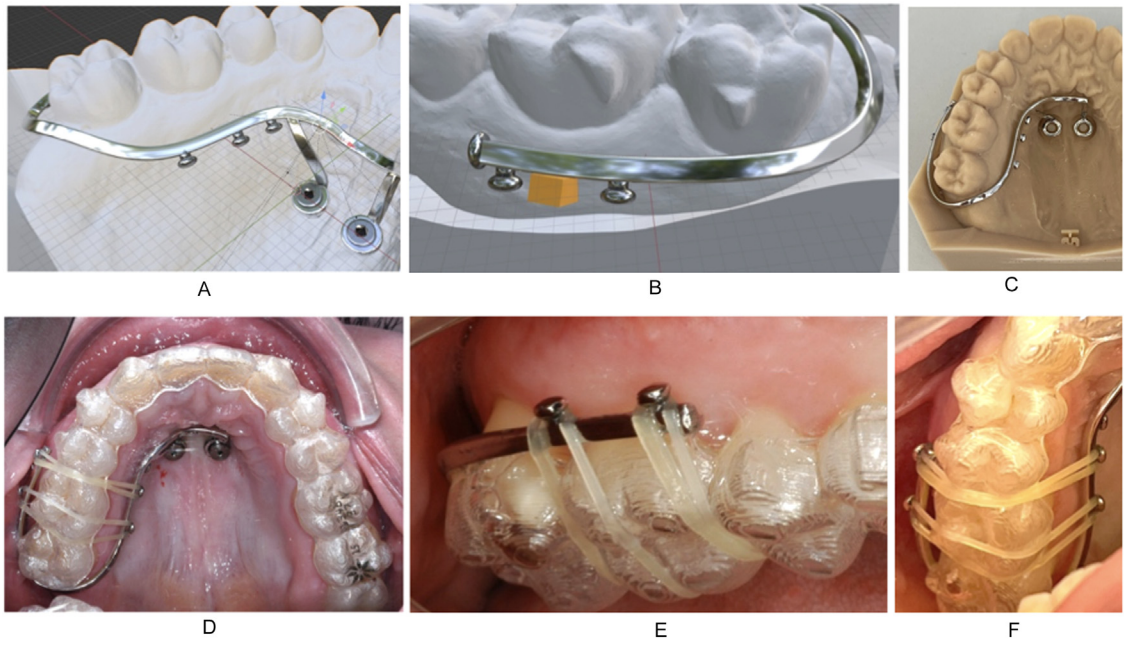


Fig. 13. (A–F) The use of CAD-CAM designed customized appliances for attaining intrusion of multiple maxillary posterior teeth in combination with CAT. (Kind courtesy: Benefit system, TADMAN design, Dr. Benedict Wilmes)

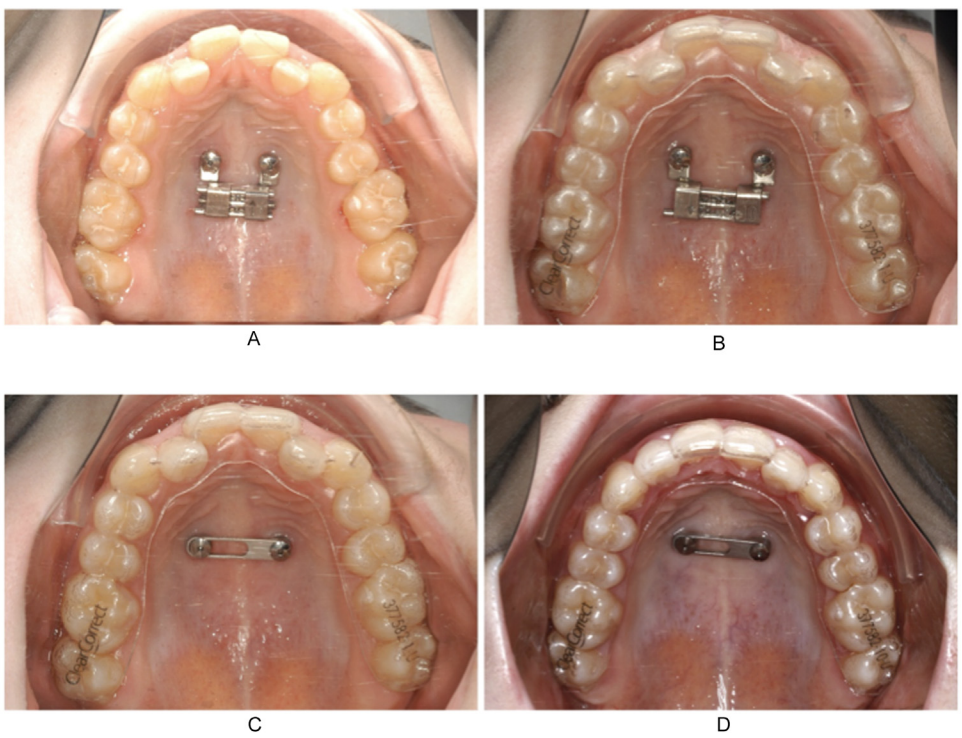


Fig. 14. (A–D) Illustration of the BMX expander as an adjunct to CAT to achieve needed maxillary expansion. (A) BMX expander placed. (B) Expansion completed, and aligners started on fresh scan. (C) Expander removed, and expansion stabilized with plate during alignment with aligners. (D) Alignment in progress, miniplate in place to maintain skeletal expansion.

occlusion and long-term stability. Mini-implants have been used to share the expansion load with the anchor teeth in mini-implant–assisted rapid palatal expansion techniques. Mini-implant–assisted rapid palatal expansion techniques appliances deriving support from mini-implants and dental structures are also referred to as hybrid hyrax appliances. For skeletal crossbite cases treated with aligners, the crossbite can be addressed first by a hybrid hyrax or bone-borne expander, also known as a BMX expander [28], as shown in Fig. 14. Once the expansion process is completed and aligners are used to obtain alignment, the BMX expander can be removed, and clinically achieved expansion can be maintained with a miniplate.

Table 2
The "HOW" of the "Golden Circle Model" for adjuncts to be utilized in either of the above situations presented in the form of a concise clinical workflow CAT, clear aligner therapy.

TAD, Temporary anchorage device, OPG, Orthopantomograph

5. "HOW" to design and plan the adjuncts: clinical workflow for the use of the different adjuncts

A pertinent point of deliberation about "HOW" to design the adjunct for CAT begins with the treatment planning decision of whether the clinician intends to use the adjunct in combination with the planned CAT or as a separate phase of treatment before the start of CAT. Among the multiple adjuncts discussed previously, adjuncts such as bootstrap or Yin-Yang attachments are used concomitantly with the aligners. In contrast, clinical situations that demand considerable movement of a group of teeth, for instance, those achieved by the Beneslider appliance, or those that need significant arch expansion, for instance, by the BMX appliance, are best addressed as a separate phase of treatment before the commencement of the actual CAT phase. This article has endeavored to summarize the "HOW" of the "Golden Circle Model" for adjuncts to be used in either of the previously mentioned situations in the form of a concise clinical workflow outlined in Table 2.

6. "WHAT" do we gain from the adjuncts: conclusion

Clear aligner systems have been demonstrated to be biomechanically inadequate to attain complex orthodontic movements based on aligner use alone, and it is the orthodontist's knowledge of biomechanics that can make any aligner system succeed or fail. The incorporation of adjuncts, such as composite attachments; interproximal reduction; power ridges; and auxiliary anchorage devices, such as brackets, buttons, mini-screws (or similar temporary skeletal anchorage devices), and intraoral elastics, especially in scenarios such as mesialization, distalization, expansion and/or extrusion, among others, all can help improve the predictability of CAT. This article, inspired by the "Golden Circle Model", addressed questions such as the "WHY, HOW, and WHAT" of adjuncts used in combination with CAT and presented an 'inside out' approach (from WHY to WHAT) to present the rationale, stepwise clinical workflow, and the advantages of these adjuncts. An astute clinician who wishes to expand the repertoire of malocclusions that can be successfully managed by CAT should judiciously plan the inclusion of such adjunct appliances in their aligner treatment planning. This may help reduce the need for refinement aligners, reduce the overall treatment duration, and provide more predictable treatment results than those attained with clear aligners alone. Technological advancements and their infusions into any profession are the order of the day [4] and how we catalyze these advancements into improving patient outcomes as clinicians will define how we chart the future of clear aligner applications in orthodontics.

References

[1] Vaid NR. Up in the air: orthodontic technology unplugged! APOS Trends Orthod 2017;7:1–5.
[2] Vaid NR. Digital technologies in orthodontics-an update. Semin Orthod 2018;24:373–5.
[3] Vaid NR. Lets talk aligners! APOS Trends. Orthod 2016;6:177–8.
[4] Vaid NR. The emperor's new clothes! APOS. Trends Orthod 2019;9:1–3.
[5] Upadhyay M, Arqub SA. Biomechanics of clear aligners: hidden truths & first principles. J World Fed Orthod 2022;11:12–21.
[6] Bowman SJ. Drastic plastic: enhancing predictability of clear aligners. In: Controversial topics in orthodontics: can we reach consensus?. Ann Arbor: Department of Orthodontics and Pediatric Dentistry, School of Dentistry, University of Michigan; 2020. p. 219–49.
[7] Kaduskar A, Kanade A. Evolution of the efficiency and predictability of clear aligner therapy. Int J Curr Res 2020;12:13074–9.
[8] Al-Nadawi M, Kravitz ND, Hansa I, Makki L, Ferguson DJ, Vaid NR. Effect of clear aligner wear protocol on the efficacy of tooth movement. Angle Orthod 2021;91:157–63.
[9] Haouili N, Kravitz ND, Vaid NR, Ferguson DJ, Makki L. Has Invisalign improved? A prospective follow-up study on the efficacy of tooth movement with Invisalign. Am J Orthod Dentofacial Orthop 2020;158:420–5.
[10] Hartshorne J, Wertheimer MB. Emerging insights and new developments in clear aligner therapy: a review of the literature. AJO-DO Clin Companion 2022;2:311–24.
[11] Hansa I, Katyal V, Ferguson DJ, Vaid N. Outcomes of clear aligner treatment with and without Dental Monitoring: a retrospective cohort study. Am J Orthod Dentofacial Orthop 2021;159:453–9.
[12] Sinek S. Start With Why: how great leaders inspire everyone to take action. London: Portfolio; 2009.
[13] Adel SM, Vaid NR, El-Harouni N, Kassem H, Zaher AR. Tip, Torque & Rotations: how accurately do digital superimposition software packages quantify tooth movement? Prog Orthod 2022;23(8).
[14] Robertson L, Kaur H, Fagundes NCF, Romanyk D, Major P, Flores Mir C. Effectiveness of clear aligner therapy for orthodontic treatment: a systematic review. Orthod Craniofac Res 2020;23:133–42.
[15] Hennessy J, EA Al-Awadhi. Clear aligners generations and orthodontic tooth movement. J Orthod 2016;43:68–76.
[16] Charalampakis O, Iliadi A, Ueno H, Oliver DR, Kim KB. Accuracy of clear aligners: a retrospective study of patients who needed refinement. Am J Orthod Dentofacial Orthop 2018;154:47–54.
[17] Cortona A, Rossini G, Parrini S, Deregibus A, Castroflorio T. Clear aligner orthodontic therapy of rotated mandibular round-shaped teeth: a finite element study. Angle Orthod 2020;90:247–54.
[18] Marya A, Venugopal A, Vaid N, Alam MK, Karobari MI. Essential attributes of clear aligner therapy in terms of appliance configuration, hygiene, and pain levels during the pandemic: a brief review. Pain Res Manag 2020;2020:6677929.
[19] Bowman SJ. Improving the predictability of clear aligners. Semin Orthod 2017;23:65–75.
[20] Nicozisis J. The Yin-yang attachment: the clear path to molar zen. The Progressive Orthodontist. Published 2017. Available from: https://princetonorthodontics.net/wp-content/uploads/2019/05/Nicozisis-Ying-Yang-Final.pdf [Accessed Month day, year].
[21] Samoto H, Vlaskalic V. A customized staging procedure to improve the predictability of space closure with sequential aligners. J Clin Orthod 2014;48:359–67.
[22] Wilmes B, Drescher D. Application and effectiveness of the Beneslider: a device to move molars distally. World J Orthod 2010;11:331–40.
[23] Wilmes B, Schwarze J, Vasudavan S, Drescher D. Combination of clear aligners and Beneslider for correction of severe midline deviation. J Clin Orthod 2021;55:675–83.
[24] Wilmes B, Tarraf N, Drescher D. Treatment of maxillary transversal deficiency by using a mini-implant-borne rapid maxillary expander and aligners in combination. Am J Orthod Dentofacial Orthop 2021;160:147–54.
[25] Wilmes B, Schwarze J, Vasudavan S, Drescher D. Maxillary Space Closure Using Aligners and Palatal Mini-Implants in Patients with Congenitally Missing Lateral Incisors. J Clin Orthod 2021;55(1):20–33.
[26] Haubrich J, Funke J, Schupp W, Wilmes B. Approaching complex orthodontic treatment cases using aligners in combination with skeletal anchorage. Journal of Aligner Orthodontics 2022;6(2):1–18.
[27] Graf S, Vasudavan S, Wilmes B. CAD/CAM Metallic Printing of a Skeletally Anchored Upper Molar Distalizer. J Clin Orthod 2020;54(3):140–50.
[28] Wilmes B, Ludwig B, Vasudavan S, Nienkemper M, Drescher D. The T-Zone: median vs. paramedian Insertion of palatal Mini-Implants. J Clin Orthod 2016;50:543–51.