

Insight into clear aligner therapy protocols and preferences among members of the American Association of Orthodontists in the United States and Canada

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ABSTRACT

Objectives: To investigate aligner treatment protocols among orthodontists in the United States and Canada and assess the factors influencing clinician choices in aligner systems, treatment protocols, and targeted malocclusions for aligners.

Materials and Methods: A validated online questionnaire was developed specifically for this research and consisted of three sections. Section 1 evaluated demographics and experience with aligners. Section 2 assessed patient selection and demands and clinician confidence in treating various malocclusions with aligners. Section 3 evaluated treatment protocols used by clinicians. The American Association of Orthodontists Partners in Research Program distributed the survey via e-mail to active members in the United States and Canada.

Results: A total of 160 providers completed the survey. Aligners were used by 65.00% of respondents, with the Invisalign system the most popular (81.25%). Aligners were mostly used for adults (97.50%). Tipping was ranked as the easiest movement (1.79 ± 1.35). Extrusion (4.34 ± 1.53) and root movement (4.31 ± 1.27) were ranked as the most difficult. Most were confident treating mild (98.8%) and moderate (82.5%) crowded cases, spacing (96.9%), and anterior crossbite (85%). Of the providers, 58.12% recommended aligners to be changed weekly. Respondents who were confident addressing some of the severe malocclusions were more likely to use Invisalign.

Conclusions: Invisalign is the most popular aligner system, and clinicians seem to be confident using it. Providers are aware of the pitfalls of aligners; they find it challenging to perform root movement and extrusion, and they seem confident treating mild to moderate malocclusions. They avoid complex cases with impactions and severe skeletal problems. (*Angle Orthod.* 2023;93:417–426.)

KEY WORDS: Clear aligner treatment; Orthodontist

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Accepted: January 2023. Submitted: October 2022.

Published Online: March 13, 2023

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INTRODUCTION

Esthetics is a major concern for orthodontic patients. The introduction of Invisalign (Align Technology, San Jose, Calif) in 1997 was a major leap in the esthetic world of orthodontics.¹ A series of preformed thermo-plastic splints are worn by patients and sequentially changed according to the treatment planned to move teeth in three dimensions.² Some advantages offered by clear aligner treatment (CAT) include that it is an esthetic alternative to braces and the ability to remove the aligners to eat and access the facial and lingual surfaces of teeth for appropriate oral hygiene practices.² On the other hand, the strict requirement of patient compliance and difficulties controlling tooth movement in three different planes of space are some of the limitations with CAT.²

CAT includes a wide range of appliances that differ in modes of action and methods of construction in the treatment of various malocclusions.³ There are significant differences in the clear aligner systems available in today's market. The first clear aligner system was used to treat minor malocclusions/irregularities; however, a new generation of clear aligner systems target more complex malocclusions that require comprehensive orthodontic treatment.² In addition, some current aligner systems are targeted directly to consumers without the direct supervision of trained professionals.⁴

This huge variety in the systems available has led clinicians planning to employ CAT to rely primarily on weak forms of published evidence (low-level, poorly designed studies) or otherwise their own clinical experience.⁵ Consensus is lacking among clinicians in their choice of aligner system, malocclusions that can be treated successfully with CAT, treatment strategies and protocols employed, and the choice of retainer afterward.

This is the first validated online survey to investigate aligner treatment protocols and preferences among orthodontists in the United States and Canada. It also assessed factors influencing clinician choices with CAT, treatment protocols, and malocclusions targeted with CAT. Therefore, the primary objective of this survey was to investigate CAT applications and practices among orthodontists in Canada and the United States. A secondary objective was to determine the level of confidence of orthodontists in treating different types of malocclusions with CAT.

MATERIALS AND METHODS

This cross-sectional study was approved by the institutional review board at the University of Connecticut Health (21X-090-2). An intensive literature review was conducted to identify the most common protocols,

preferences, and factors related to clinician choices in CAT.

A preliminary electronic survey was developed specifically for this project using Google (Mountain View, Calif) Forms online survey tool. It included three sections and 48 questions that were evaluated for content validity by 14 consultant orthodontists (Appendix 1). In addition, the questions were rated on a three-point scale. The content validity ratio was calculated for each question according to the method by Lawshe.⁶ Nine questions were not significant at the critical level; therefore, they were eliminated from the final version.

The final version of the questionnaire consisted of three sections and 39 questions. Section 1 included questions related to demographics and clinical experience with CAT. Section 2 had questions related to patient selection, satisfaction, and demands. In addition, section 2 assessed clinician confidence in treating various malocclusions. Section 3 had questions related to treatment protocols and adjustments used by clinicians (Appendix 1). The questionnaire was reviewed by the American Association of Orthodontists (AAO) Survey Review Committee. Once approved, the AAO Partners in Research Program distributed the survey via e-mail to active members in the United States and Canada. To increase the response rate, the e-mail was distributed twice with a reminder e-mail to randomly selected population samples. The e-mail was sent to two different groups of randomly selected active members ($n = 2116$ and 2100). Participation in the survey was voluntary, and the average time to complete the survey was 10 minutes.

Statistical Analysis

Demographics and practice experience as well as responses to survey questions were summarized using frequencies and percentages. Fisher's exact tests were used to test the associations between confidence in using clear aligners to manage a particular malocclusion (confident/very confident vs not confident). In addition, grouped bar plots were used to highlight the significant associations. P values smaller than .05 were considered statistically significant. All statistical analyses were performed in R version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

The survey was distributed to 4216 active members of the AAO. A total of 160 providers completed the survey. The response rate was 3.8%.

Table 1 describes the sample characteristics and basic information regarding clear aligner experiences. CAT was used by 65.00% of respondents. It constituted more than 20% of practice for 47% of respondents.

Table 1. Basic Information

Question ^a	Response	Frequency, n (%)	Total Respondents, n
Sex	Female	46 (28.75)	160
	Male	114 (71.25)	
Age (mean ± SD)	52.56 ± 11.94		160
Years of practice (mean ± SD)	22.69 ± 12.78		159
Clinical practice setting: university hospital based (faculty practice)	Yes	21 (13.2)	160
Clinical practice setting: private practice (associate orthodontist, dental center, owner [solo/partnership])	Yes	149 (93.1)	160
How are you currently using clear aligners in your clinical setting?	I have used them in the past.	1 (0.62)	160
	I use them but in selective cases.	55 (34.38)	
	I use them very frequently in my practice.	104 (65.00)	
Clear aligners constitute what percentage of your practice?	I don't use clear aligners in my practice.	1 (0.6)	160
	0%–20%	84 (52.5)	
	20%–40%	41 (25.6)	
	40%–60%	27 (16.9)	
	60%–80%	7 (4.4)	
	80%–100%	0 (0)	
If you are an aligner provider, when did you start providing aligners to the patients?	1–2 years ago	11 (6.88)	160
	3–5 years ago	27 (16.88)	
	6–10 years ago	32 (20.00)	
	More than 10 years ago	90 (56.25)	
What is your choice of commercial aligner systems? (Check all that apply.)	Invisalign by Align Technology (San Jose, Calif)	130 (81.25)	160
	Clarity (3M, St Paul, Minn)	18 (11.25)	160
	In-house aligners (university laboratory) + fabricated in my office	18 (11.25)	160
	Other	50 (31.25)	160

^a SD indicates standard deviation.

Of the respondents, 56.25% had been using it for more than 10 years. Invisalign was the most popular type (81.25%).

Table 2 summarizes questions related to patient selection, satisfaction, and demands for CAT. Of the orthodontists, 97.5% primarily used CAT to treat adult patients. In addition, 63.75% used CAT for patients between 31 and 45 years old. Clear aligners were equally used for both sexes by 63.75% of orthodontist respondents. Interestingly, 97.5% of orthodontists believed that esthetic concern was the primary reason for seeking CAT. In addition, only 61% of orthodontists reported that their patients were always content with the results achieved.

Table 3 describes respondent confidence in treating malocclusions and rankings of tooth movements achieved with aligners. Tipping movement was ranked as the easiest (1.79 ± 1.35). Extrusion (4.34 ± 1.53) and root movement (4.31 ± 1.27) were ranked as the most difficult tooth movements with CAT. Approximately 98.8% of the orthodontists were confident in treating mild/less severe malocclusions with CAT. Of the orthodontists, 82.5% used CAT for crowding, 96.9% for spacing, and 85% for anterior crossbite. However, only 10% of orthodontists reported that they used CAT for impaction, 22.5% for facial asymmetry, and 30.6% for severe skeletal discrepancies.

Tables 4 and 5 depict treatment protocols and adjustments of cases treated with CAT. A total of 26.87% of orthodontists said that they avoided extraction with CAT, but 58.75% reported extracting single teeth: a mandibular incisor. Elastics were the most common auxiliaries (92.50%) used by orthodontists for treating various malocclusions. Other adjuncts included inter-radicular buccal temporary anchorage devices (TADs) used by 50% of the orthodontists. Interestingly, 43.75% of the orthodontists used limited treatment with braces, whereas 70% of the orthodontists use sectional fixed appliances when treating with CAT.

Importantly, 58.12% recommended aligners to be changed weekly. Of the orthodontist respondents, 83.75% requested overcorrection in their digital set up, especially for tooth rotations (78.12%). Refinements were needed most of the time (8.44 ± 1.77 on a scale from 1 [rarely] to 10 [100% of the time]), as predicted vs achieved outcomes were substantially different.

Interestingly, 56.25% of orthodontists agreed that fixed braces had better three-dimensional (3D) control of tooth movement and resulted in better occlusal contacts. In addition, 79.38% of respondents did not use any adjuncts to accelerate tooth movement. Notably, 59% of respondents were using in-house

Table 2. Patient Selection, Satisfaction, and Demands for Clear Aligner Therapy

Question	Response	Frequency, n (%)	Total Respondents, n
In which sex do you more frequently use clear aligners?	Equal number	102 (63.75)	160
	Female	57 (35.62)	
	Male	1 (0.62)	
In your practice, clear aligners are most frequently used for individuals in what age range?	Between 18 and 30 years old	38 (23.75)	160
	Between 31 and 45 years old	102 (63.75)	
	Between 46 and 60 years old	9 (5.62)	
	Younger than 18 years old	11 (6.88)	
Patients' choice for clear aligner treatment is based on which of the following factors? (Check all that apply.)	Advertising and marketing	92 (57.50)	160
	I diagnosed the case suitable to be treated with aligners	125 (78.12)	
	My clinical judgment	125 (78.12)	
	Recommended by friends and family	73 (45.62)	
	Referred by or suggested by patients' dentists	36 (22.50)	
In my practice, patients seek treatment with clear aligners because of which the following factors? (Check all that apply.)	Other reasons related to esthetics and personal preference	15 (9.38)	160
	Better oral hygiene	6 (3.75)	
	Aesthetically pleasing	156 (97.50)	
	Convenient	86 (53.75)	
	Ease of wear	85 (53.12)	
	Faster treatment and less chair side	33 (20.62)	
	Other factors related to eating, recommendations from family, and fewer emergency appointments	8 (5.0)	
Most of my patients with clear aligners belong to which category? (Check all that apply.)	Adult patients	156 (97.50)	160
	Orthognathic surgery patients	7 (4.37)	
	Periodontal patients (who received periodontal treatment and that are stable)	16 (10.00)	
	Preprosthetic patients	14 (8.75)	
	Other (retreatment and interceptive)	3 (1.88)	
	Teen patients	46 (28.75)	
My patients are happy and satisfied with the results of aligner therapy.	Always	97 (60.62)	160
	Never	2 (1.25)	
	Sometimes	61 (38.12)	

aligners for limited treatment (39.86%), relapse treatment (40.56%), or minor adjustments (44.76%). Of the orthodontists, 83.12% preferred Essix retainers following CAT.

Appendix 2 shows the association between confidence in treating severe malocclusions and the aligner system used. The significant associations are highlighted in Figure 1. Orthodontists who were using CAT for severe malocclusions were more likely to use Invisalign and less likely to use 3M (St Paul, Minn) than those who were not confident (Appendix 2, Figure 1).

- Increased overjet more than 8 mm: 90% of confident respondents used Invisalign to treat severe overjet compared with 76% of nonconfident respondents who used Invisalign to treat severe overjet; the difference between the groups was statistically significant ($P = .022$).
- Posterior crossbite: 89% of confident respondents used Invisalign to treat posterior crossbite compared with 75% of the nonconfident respondents who used Invisalign to treat posterior crossbite cases; the difference between the groups was statistically significant ($P = .040$). On the other hand, 4% of confident respondents used 3M for posterior cross-

bite treatment, whereas 15% of nonconfident respondents used 3M for posterior crossbite; the difference between the groups was statistically significant ($P = .012$).

- Anterior openbite: 88.5% of confident respondents used Invisalign to treat anterior openbite cases compared with 48.3% of nonconfident respondents who used it for the same purpose; differences between the groups were statistically significant ($P < .001$). On the other hand, 8% of confident respondents used 3M to treat openbite malocclusion, whereas 28% of nonconfident respondents used 3M aligners for the same purpose; the difference between the groups was significant ($P = .006$).

DISCUSSION

The primary aim of this cross-sectional study was to provide an overview of how clinicians perceive CAT and delve into common clinical practices related to its use. The strengths of this study were the systematic method used to create a validated survey instrument and the random sample selected by the AAO Partners in Research Program for its distribution.

Table 3. Section 2: Malocclusion and Ease of Tooth Movement

Question: How confident are you with using clear aligners to manage the following malocclusions?	Confident and Very Confident: Frequency, n (%)	Total Respondents, n
Mild crowding, less than 6 mm	158 (98.8)	160
Moderate crowding, 6.8 mm	132 (82.5)	
Severe crowding, more than 8 mm	64 (40)	
Generalized spacing	155 (96.9)	
Increased overjet, more than 8 mm	62 (38.8)	
Deep overbite	98 (61.3)	
Midline discrepancies, greater than 2 mm	101 (63.1)	
Anterior crossbite	136 (85)	
Posterior crossbite	71 (44.4)	
Scissor bite	70 (43.8)	
Anterior open bite	131 (81.3)	
Distalization	95 (59.4)	
Periodontally compromised patients	132 (82.5)	
Extraction	62 (38.8)	
Canting	49 (30.6)	
Missing teeth, hypodontia cases	110 (68.8)	
Impacted teeth, canines or centrals	16 (10)	
Severe Class II and Class III skeletal problems requiring orthognathic surgery	49 (30.6)	
Facial asymmetry	36 (22.5)	
Rank the following from the easiest to the most difficult movement achieved with aligners in your practice (easiest movement number 1 and most difficult number 6)	Mean ± SD	
Tipping	1.79 ± 1.35	160
Intrusion	3.07 ± 1.60	
Rotation	3.36 ± 1.40	
Translation	3.88 ± 1.37	
Root movement	4.31 ± 1.27	
Extrusion	4.34 ± 1.53	

^a SD indicates standard deviation.

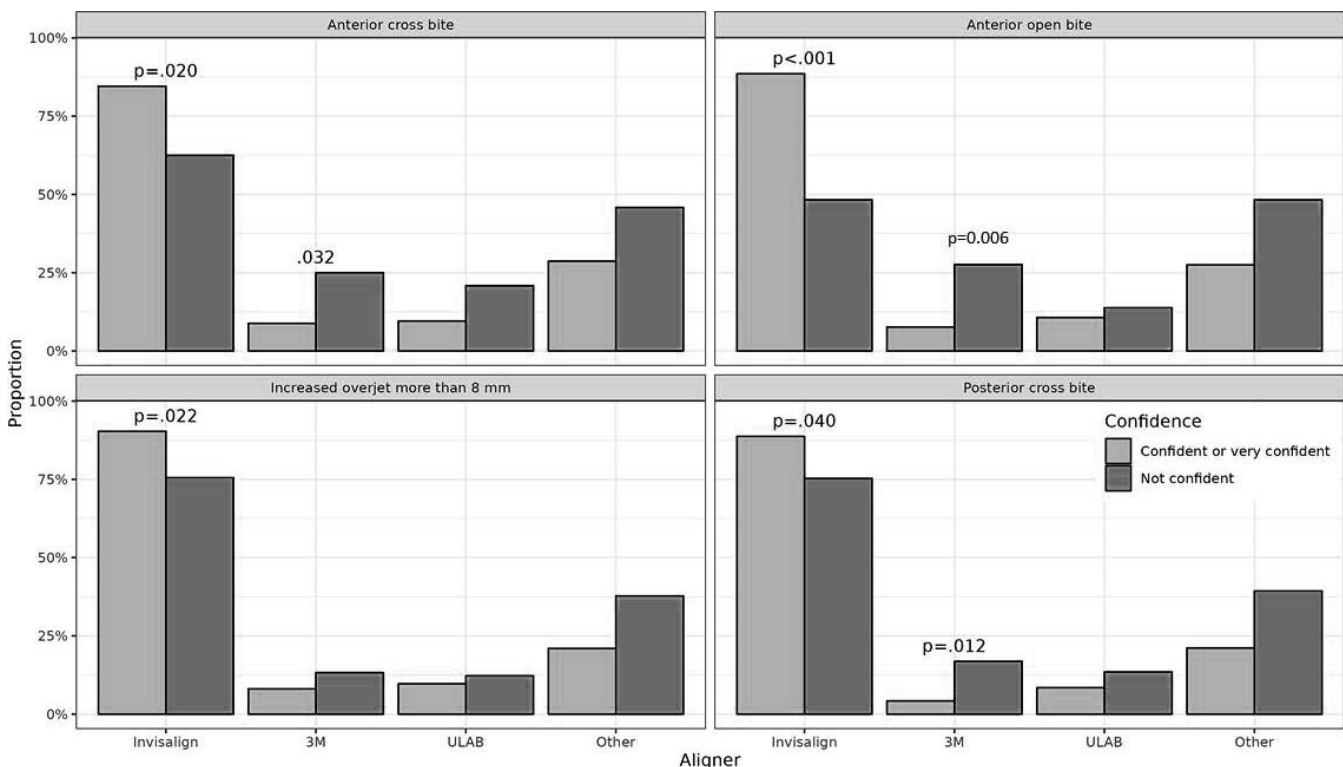


Figure 1. Association between the confidence in treating severe malocclusions and the aligner system used.

Table 4. Section 3A: Treatment Protocols, Management, and Adjustments With Clear Aligners^a

Question	Response	Mean ± SD or Frequency, n (%)	Total Respondents, n
What type of scanner do you use for submitting the treatment plans for your aligner patients?	3shape (Copenhagen, Denmark)	17 (10.62)	160
	Carestream (Rochester, New York)	4 (2.50)	
	Itero (Align Technology, San Jose, California)	126 (78.75)	
	Other scanners and conventional impression	13 (8.13)	
What is your recommended protocol for changing aligner trays?	10 days	8 (5.00)	160
	2 weeks	42 (26.25)	
	Weekly	93 (58.12)	
	Other: from 3 days to 14 days, altered as necessary for the patient's treatment plan or system used	17 (10.62)	
What ancillary treatments do you use in conjunction with clear aligners? (Check all that apply.)	IPR	160 (100.00)	160
	Attachments	159 (99.38)	
	Buttons	137 (85.62)	
	Elastics	148 (92.50)	
	TADs	44 (27.50)	
	Sectional fixed for certain movements	93 (58.12)	
	Other: fixed functional (Carrier), clear collection pliers, bite turbos	9 (5.62)	
Indicate which of the following TADs you use in your clear aligner therapy.	Buccal shelf	14 (8.75)	160
	I don't use TADs	20 (12.50)	
	Infra-zygomatic	5 (3.12)	
	Inter-radicular buccal TADs	80 (50.00)	
	Palatal TADs	36 (22.50)	
	Retromolar TADs	5 (3.12)	
Indicate which of the following extraction patterns you commonly use in your clear aligner therapy. (Check all that apply.)	I don't extract with clear aligners	43 (26.87)	160
	All extraction patterns	32 (20.00)	
	Single tooth/mandibular incisor	94 (58.75)	
	Single tooth/premolar	26 (16.25)	
	Two premolars	28 (17.50)	
	Four premolars	24 (15.00)	
	No appliances	39 (24.38)	
Indicate which of the following appliances you use most prior to clear aligner therapy. (Check all that apply.)	Full fixed appliance	19 (11.88)	160
	Expanders	78 (48.75)	
	Limited fixed appliance	70 (43.75)	
	Distalization appliance	51 (31.87)	
	Functional appliances for teens	12 (7.50)	
	Head gear	8 (5.00)	
	Others: bite planes, No manufacturer, Carrier motion (Henry Schein, Carlsbad, California)	5 (3.13)	
	None	4 (2.50)	
Which parts of the preliminary treatment plan received by the digital set up do you usually modify? (Check all that apply.)	Attachments' size	96 (60.00)	160
	Attachment shape or number	96 (60.00)	
	IPR amount and location	96 (60.00)	
	Auxiliaries used	47 (29.38)	
	All of the above	63 (39.37)	
	Number of trays used	57 (35.62)	
	Range of movements	73 (45.62)	
	None	4 (2.50)	
How often do you use refinements?	1 (rarely) to 10 (100% of the time)	8.44 ± 1.77	160
Reasons for refinement. (Check all that apply.)	Noncompliant patient	82 (51.25)	160
	Poor tracking	121 (75.62)	160
	Goals not achieved	141 (88.12)	160
	Minor adjustments	135 (84.38)	160
	Other: fishing, occlusal adjustments and rotations, always need refinements	4 (2.50)	160
	Do you request overcorrection in your digital set up?	Yes	134 (83.75)

^a IPR indicates interproximal reduction; SD, standard deviation; and TAD, temporary anchorage device; MARA, mandibular anterior repositioning appliance.

Table 5. Section 3B: Treatment Protocols, Management, and Adjustments With Clear Aligners

Question	Response	Frequency, n (%)	Total Respondents, n
What type of movements do you tend to overcorrect in your digital set up? (Check all that apply.)	Torque	89 (55.62)	160
	Intrusion	95 (59.38)	
	Tipping	28 (17.50)	
	Rotation	125 (78.12)	
	Extrusion	76 (47.50)	
	Translation	27 (16.88)	
Which of the following treatment approaches do you use in conjunction with clear aligners? (Check all that apply.)	None	12 (7.50)	160
	Sectional fixed braces	28 (17.50)	
	Prealigner fixed braces correction	112 (70.00)	
	Orthognathic surgery	57 (35.62)	
	Full fixed braces	37 (23.12)	
	Other: smooth incisal edges and expanders	41 (25.63)	
There is no difference in the treatment outcomes between fixed braces and aligners.	Strongly agree + agree	2 (1.25)	160
	Strongly disagree+ disagree	44 (27.50)	
	Neutral	83 (51.88)	
Fixed braces have better 3D control for all movements and results in better occlusal contacts.	Strongly agree + agree	33 (20.62)	160
	Strongly disagree+ disagree	90 (56.25)	
	Neutral	46 (28.57)	
The movement/s that is/are most accurately expressed with clear aligners in my clinical observation is/are: (Check all that apply.)	Tipping	24 (15.00)	160
	Rotation	100 (62.50)	
	Intrusion	22 (13.75)	
	Extrusion	26 (16.25)	
	Torque	5 (3.12)	
	Translation	3 (1.87)	
	Root movement	3 (1.87)	
Which of the following adjunct therapies you use with aligners? (Check all that apply.)	None	1 (0.62)	160
	Micro-osteoperforations	127 (79.38)	
	Laser therapy	11 (6.88)	
	Vibration therapy	8 (5.00)	
	Other: piezocision, OrthoPulse, bite wafer	20 (12.50)	
Do you use in-house aligners?	No	5 (3.13)	160
	Yes	101 (63.12)	
If yes for question 17, in which clinical scenarios do you use in-house aligners? (Check all that apply.)	Limited treatment	59 (36.88)	143
	Relapse cases	57 (39.86)	
	Minor adjustments	58 (40.56)	
	None	64 (44.76)	
	Major adjustments	21 (14.69)	
Do you use dental monitoring with clear aligner therapy?	No	3 (2.10)	160
	Yes	127 (79.37)	
What is your preferred retention protocol for cases treated with clear aligners? (Check all that apply.)	Essix	33 (20.62)	160
	Vivera (Align Technology, San Jose, California)	133 (83.12)	
	Bonded retainer	41 (25.63)	
	Hawley retainer	69 (43.13)	
	Other: combination, revolution spring aligner, Zendura (Bay materials LLC, Fremont, California), the aligner themselves	34 (21.25)	

With the increased number of adults seeking orthodontic treatment, the demand for esthetic appliances has increased significantly.³ This study showed that esthetic concern is perceived as the primary reason for patients seeking CAT for orthodontic treatment. It was previously reported that the motivation for patients requesting aligners for treatment is primarily esthetic.² The survey further showed that patients were generally satisfied with the outcomes with CAT. In addition, studies assessing patient satisfaction with CAT showed that Invisalign was

associated with improved oral health and greater satisfaction compared with fixed appliances.^{7,8}

Tipping movement was ranked as the easiest and extrusion and root movement were ranked as the most difficult to achieve. Aligners being fabricated from thermoplastic materials do not offer the flexibility to control force systems delivered to teeth,⁹ in contrast with fixed appliances in which force delivery is controlled by altering wires and brackets.¹⁰ Mechanical properties of aligner materials can change after thermoforming or exposure to the oral environment,

which affects force delivery and final outcomes.¹¹ It was shown that the properties of polymers hinder their ability to deliver an appropriate load system (moment of a couple) for precise control of root movement.¹² With CAT, forces can be easily applied away from the center of resistance, creating a moment of a force that produces a “tipping” movement,¹³ which is the default movement achieved with CAT.³ Therefore, malocclusions that can be treated by tipping of teeth (crowding, spacing, crossbites, openbites) are more easily corrected by CAT.^{12,14} It was reported that CAT works better for intrusion rather than extrusion.¹⁴ Therefore, extrusion of teeth has been described as one of the least predictable movements achieved with CAT in the literature and in this study.³

Earlier, CAT relied on a shape-molding effect to achieve desired results.² Auxiliary elements (attachments, elastics, power ridges, bite ramps, TADs, etc) were added to improve treatment efficacy and range of movement.¹⁵ Attachments help improve the predictability of specific tooth movements such as rotations and extrusion, and their tactical arrangement and morphology is predicted to enhance force delivery.¹⁴ Interproximal reduction, the main mechanism to create space, is virtually planned and adjusted with the new 3D treatment simulation. Extraction to resolve severe arch length discrepancy seemed to be avoided by some respondents because of its unpredictable outcome with CAT,¹⁶ whereas others reported the possibility of extracting a single tooth (mandibular incisor). In challenging cases, integration of elastics aids in addressing severe sagittal and transverse discrepancies. In addition, in the current study, orthodontists preferred adjuncts such as buccal mini-implants or limited or sectional fixed braces over extraction to resolve these severe discrepancies.¹⁵

Unlike comprehensive treatment with braces, treatment outcome with CAT relies on the clinicians' experience with the virtual 3D set up software in addition to coming up with a comprehensive treatment plan for their patients.¹⁷ It was shown that patients' choice for CAT was primarily based on the providers' sound clinical judgment and proper case diagnosis (Table 2).

Orthodontists who responded to the survey preferred aligners to be changed every 7 days. Al-Nadawi et al. found that 2-week changes were more accurate for some posterior movements, but this was not clinically significant, and a 7-day regimen is an acceptable protocol.¹⁸ In addition, the current study indicated that regardless of whether overcorrection was prescribed for rotated teeth, refinements were needed as the predicted and achieved outcomes did not match. A previous study showed that the outcome achieved with CAT was 50% for the majority of tooth movements.¹⁴ In

addition, rotations of more than 15 degrees constitute a challenge to treat with CAT.¹⁹ Because of the differences between predicted and achieved outcomes, orthodontists resort to refinements to achieve satisfactory outcomes.¹⁴

More than 50% of the orthodontists agreed that braces provided better 3D control of tooth movement. Despite the advantages CAT offers in terms of esthetics, fewer emergencies, comfort, and periodontal health,² it still lacks efficiency in treating moderate to complex malocclusions. Buschang et al. recommended CAT for simple malocclusions.⁵ It was indicated that aligners were not as efficient as braces in torque control, producing adequate occlusal contacts and posttreatment retention.¹⁴ Shortened treatment duration and significantly reduced chair time in mild cases appeared to be the only significant advantages of CAT over conventional systems.²⁰

Adjunct therapies for accelerating orthodontic tooth movement are not popular with CAT (79.38% not using adjuncts). This study showed vibration as the most commonly used modality for acceleration with aligners (12.50%), although the literature is controversial regarding the effects of vibration on the rate of tooth movement.²¹ In this survey, advocates of in-house aligners (n = 59) used them for minor adjustments (44.76%) and the treatment of relapse malocclusion (40.56%) or limited treatment (39.86%). Unlike other aligner systems, they are economical and do not require an outside service, duration of treatment is very fast, and the orthodontist has full control over the workflow.²² With the emphasis on improving treatment efficacy with regard to monitoring patients and reducing clinical and financial burdens associated with an increased number of appointments, the popularity of dental monitoring (DM) is increasing among practitioners. This study showed that 20.62% of orthodontists used DM with CAT. Hansa et al. indicated that the number of appointments were reduced by 3.5 visits with DM with Invisalign, and aligner tracking was improved in the DM group.²³ However, DM is expensive and may increase the financial economic burden on patients.

Essix retainers were the most popular retainers following CAT and were used by 83.12% of the orthodontists. Essix retainers offer several benefits: they are easy and quick to fabricate, they provide an opportunity for better oral hygiene maintenance, and they are strong and flexible enough to act as a positioner or nightguard.²⁴

The popular Invisalign system has evolved through the years. Malocclusions that were impossible to manage with Invisalign a decade ago can now be treated with increased patient satisfaction. Also, efficacy of the treatment was enhanced by the addition

of auxiliaries and, recently, with the introduction of optimized attachments that are placed automatically by the manufacturer's software to provide better control of tooth movement. The 3M Clarity aligners, developed by Dr Warshawski, are considered unique because their improvement and accuracy relies primarily on prospective analysis of preliminary data related to their use.²⁵ Data regarding the efficiency of CAT systems is still deficient. However, both systems seem to be commonly used among clinicians.

The limitations of this cross-sectional survey study included the low response rate despite two rounds of distribution. This may have been attributed to the length of the survey and no incentives for the respondents. Also, it must be noted that most e-mail message-based surveys with high response rates were done before 1995 when e-mail messages were a novel tool; rates have decreased as novelty has diminished.^{26,27} On the other hand, the mean age of the respondents was 52.56 ± 11.94 years old; therefore, reported CAT practices and protocols might have been different if this survey was distributed to residents or new graduates.

CONCLUSIONS

- Invisalign is the most popular clear aligner system, and clinicians seem to be confident using it.
- Providers are aware of the pitfalls of CAT; they find it challenging to perform root movement and extrusion with aligners. They seem confident treating mild to moderate malocclusions with clear aligners and avoid complex patients with impactions or severe skeletal problems.
- Extraction is often avoided; integration of elastics, TADs, expanders, or sectional fixed appliances is preferred to resolve severe discrepancies.
- Providers prefer the 1-week change protocol, and refinements are often required to reach desired goals.
- In-house aligners and dental monitoring are starting to gain popularity with CAT.

SUPPLEMENTAL DATA

Appendixes 1 and 2 with supplemental data are available online.

REFERENCES

1. Boyd RL, Miller R, Vlaskalic V. The Invisalign system in adult orthodontics: mild crowding and space closure cases. *J Clin Orthod*. 2000;34:203–212.
2. Weir T. Clear aligners in orthodontic treatment. *Aust Dent J*. 2017;62:58–62.
3. Rossini G, Parrini S, Castrolforio T, Deregibus A, Debernardi CL. Efficacy of clear aligners in controlling orthodontic tooth movement: a systematic review. *Angle Orthod*. 2015;85:881–889.
4. Katzman J, Fenkell A, Katzman D, Yancey C, Chapman J. Arrangements for remote orthodontic treatment. Google Patents; 2018. Inventors: Jordan Katzman, Alex Fenkell, David Katzman, Christopher Yancey, Josh Chapman, Jessica Cicurel Current Assignee: SDC US Smilepay SPV US Patent number: US20190252067A1 Full date: 4-29-2019
5. Buschang PH, Shaw SG, Ross M, Crosby D, Campbell PM. Comparative time efficiency of aligner therapy and conventional edgewise braces. *Angle Orthod*. 2014;84:391–396.
6. Lawshe CH. A quantitative approach to content validity. *Pers Psychol*. 1975;28:563–575.
7. Azaripour A, Weusmann J, Mahmoodi B, et al. Braces versus Invisalign®: gingival parameters and patients' satisfaction during treatment: a cross-sectional study. *BMC Oral Health*. 2015;15:1–5.
8. Pacheco-Pereira C, Brandelli J, Flores-Mir C. Patient satisfaction and quality of life changes after Invisalign treatment. *Am J Orthod Dentofacial Orthop*. 2018;153:834–841.
9. Kwon J-S, Lee Y-K, Lim B-S, Lim Y-K. Force delivery properties of thermoplastic orthodontic materials. *Am J Orthod Dentofacial Orthop*. 2008;133:228–234.
10. Hemingway R, Williams R, Hunt J, Rudge S. The influence of bracket type on the force delivery of Ni-Ti archwires. *Eur J Orthod*. 2001;23:233–241.
11. Ryokawa H, Miyazaki Y, Fujishima A, Miyazaki T, Maki K. The mechanical properties of dental thermoplastic materials in a simulated intraoral environment. *Orthod Waves*. 2006;65:64–72.
12. Bollen A-M, Huang G, King G, Hujoel P, Ma T. Activation time and material stiffness of sequential removable orthodontic appliances. Part 1: ability to complete treatment. *Am J Orthod Dentofacial Orthop*. 2003;124:496–501.
13. Lee BW. The force requirements for tooth movement part I: tipping and bodily movement. *Aust Orthod J*. 1995;13:238–248.
14. Upadhyay M, Arqub SA. Biomechanics of clear aligners: hidden truths & first principles. *J World Fed Orthod*. 2021.
15. Bowman SJ, Celenza F, Sparaga J, Papadopoulos MA, Ojima K, Lin J. Creative adjuncts for clear aligners, part 3: extraction and interdisciplinary treatment. *J Clin Orthod*. 2015;49:249–262.
16. Dai F-F, Xu T-M, Shu G. Comparison of achieved and predicted tooth movement of maxillary first molars and central incisors: first premolar extraction treatment with Invisalign. *Angle Orthod*. 2019;89:679–687.
17. Gregg BR. *A Survey of Invisalign ClinCheck Modifications and the Types of Cases Treated Using Invisalign: General Dentists vs. Orthodontists*. Buffalo, NY: State University of New York at Buffalo; 2007. Master's thesis
18. 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: a randomized clinical trial. *Angle Orthod*. 2021;91:157–163.
19. Simon M, Keilig L, Schwarze J, Jung BA, Bourauel C. Forces and moments generated by removable thermoplastic aligners: incisor torque, premolar derotation, and molar distalization. *Am J Orthod Dentofacial Orthop*. 2014;145:728–736.
20. Zheng M, Liu R, Ni Z, Yu Z. Efficiency, effectiveness and treatment stability of clear aligners: a systematic review and meta-analysis. *Orthod Craniofac Res*. 2017;20:127–133.

21. Lyu C, Zhang L, Zou S. The effectiveness of supplemental vibrational force on enhancing orthodontic treatment. A systematic review. *Eur J Orthod*. 2019;41:502–512.
22. Tozlu M, Ozdemir F. In-house aligners: why we should fabricate aligners in our clinics? *Turk J Orthod*. 2021;34:199–201.
23. 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;159:453–459.
24. Sheridan J, LeDoux W, McMinn R. Essix retainers: fabrication and supervision for permanent retention. *J Clin Orthod*. 1993;27:37–45.
25. Warshawsky N. *Preliminary Efficacy of Tooth Movement in Clarity Aligners* [master's thesis]. Boston, Mass: Boston University; 2019.
26. Sheehan KB. E-mail survey response rates: a review. *J Comput-Mediat Comm*. 2001;6.
27. Groves RM, Cialdini RB, Couper MP. Understanding the decision to participate in a survey. *Public Opinion Q*. 1992; 56:475–495.