Review

How Efficient Are Clear Aligners? Clear Aligners vs Traditional Orthodontic Treatment: A Systematic Review

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ABSTRACT

Purpose: The purpose of the present review is to update knowledge of the literature and better understand the efficiency and abilities of clear aligners and to clarify their indications for use.

Materials and Method: The study question was defined as "How efficient is orthodontic treatment with clear aligners in comparison to fixed orthodontic treatment in patients with permanent dentition?" An Internet-based search was performed with 6 databases: Medline, PubMed, Clinical Key, ProQuest Dissertations and Theses, Dentistry and Oral Sciences Source (EBSCO Host), and the Cochrane Library. The final search was run in January 2014. Key words used were clear aligner, eCligner, Invisalign, and AsoAligner.

Results: We retrieved 110 publications from the databases. After reviewing titles and abstracts, case reports and clinical studies reporting treatment outcomes on segmental dental arches (i.e., anterior dentition) were excluded. Finally, 3 studies that addressed the study question were included in the review.

Conclusion: Not enough studies were available to arrive at definite conclusions to compare clear aligner and fixed orthodontic treatment. In simpler cases, Invisalign may result in treatment outcomes as good as those of traditional orthodontic treatment. However, controlled clinical studies are necessary to define and support the abilities and limits of clear aligner therapy with evidence. (*Turkish J Orthod* 2015;27:106–110)

KEY WORDS: Clear aligner, Fixed orthodontic treatment, Removable

INTRODUCTION

Aesthetics is one of the major concerns among patients who seek orthodontic treatment. To address the increasing aesthetic demand for an alternative to conventional braces, investigators have developed several solutions, such as ceramic or composite braces, lingual orthodontics, and clear aligners. In 1990s, clear-aligner systems made substantial progress with advancing computer technologies and have been gaining popularity since then. Today, various brands of clear aligners are on the market. Basically, they use the same material—semielastic polyurethane, a thin, transparent plastic—but vary in cost and software process.

This treatment modality has several advantages: better aesthetics during treatment, better oral hygiene, and improved patient comfort.[1] The range of indications for clear aligners include mild to moderate crowding or spacing (1–6 mm), nonskeletal open bite and constriction, and mild anteroposterior malocclusions (<2 mm) in permanent dentition.[2] The manufacturers also suggest criteria to guide clinicians in case selection. These criteria are helpful but not restrictive. The final decision about a patient's suitability for treatment with clear aligners depends on the clinician's experience and the

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Table 1. Summary of database search results

	Clear aligner	Invisalign	eCligner	AsoAligner
PubMed	21	103	0	0
Medline	14	104	0	0
ProQuest Dissertations and Theses	18	86	0	0
Clinical Key Elsevier	36	59	0	0
Dentistry and Oral Sciences Source (EBSCO Host)	8	12	0	0
The Cochrane Library	1	6	0	0

patient's treatment expectations. However, clear aligners have limitations; for example, patient compliance is a must for a successful outcome.

Clear aligners have been widely studied in many aspects: periodontal effects, material properties, activation sequence, and patient compliance.[3–6] Still, there seems to be a confusion about their appropriateness for individual cases. The purpose of the present review is to update our knowledge of the literature and to better understand the efficiency and abilities of clear aligners to clarify their indications for use.

MATERIAL AND METHODS

The methodology of this systematic review was designed according to the guidelines described by Pai *et al* (2004)[7]. The clinical intervention that is the focus of this study is orthodontic clear aligner treatment, and the comparison intervention is fixed orthodontic treatment. The patient group chosen was patients with permanent dentition and full-arch treatment. The study question was "How efficient is orthodontic treatment with clear aligners in comparison to fixed orthodontic treatment in patients with permanent dentition?"

Two researchers individually performed computerized searches using Internet-accessible databases: Medline (from 1966 to January 7, 2014), PubMed (from 1966 to January 7, 2014), Clinical Key (from 1980 to January 10, 2014), ProQuest Dissertations and Theses (from 1980 to January 10, 2014), Dentistry and Oral Sciences Source (EBSCO Host) (from 1980 to December 25, 2013), the Cochrane Library (from 1980 to December 30, 2013). Key words used were clear aligner, eCligner, Invisalign, and AsoAligner. The literature search was limited to publications in scholarly (peer-reviewed) journals and thesis studies, regardless of publication type and language. Among the listed studies for each key word, eligibility of the articles was first determined according to their title and abstract.

Inclusion criteria for initial selection of appropriate articles from the list of abstracts consisted of full-arch orthodontic treatment with a clear aligner system, no history of previous orthodontic treatment, clear aligner treatment being the primary treatment (not a supplementary or relapse treatment), and clinical research that compared treatment outcomes of clear aligner systems and fixed treatment. After that, full texts of the selected studies were collected and read. Full articles were also obtained for abstracts that did not provide enough relevant information. Reference lists of the selected articles were also searched for relevant articles that may have been missed by search engines. Case reports and clinical studies reporting treatment outcomes on segmental dental arches (i.e., anterior dentition) were excluded.

RESULTS

The result of Internet-based database search is summarized in Table 1. Invisalign was found to be the sole aligner system studied in the literature. In total, 3 clinical trials compared treatment efficiency of Invisalign and fixed orthodontic treatment (Table 2), and all 3 articles are included in this review.

In the retrospective study of Djeu *et al.*,[8] records of 2 groups of 48 patients (braces and Invisalign) were evaluated according to the discrepancy index and graded with the objective grading system (OGS) of the American Board of Orthodontics (ABO). Using the discrepancy index, Djeu *et al.*[8] analyzed pretreatment records in 10 categories: overjet, overbite, anterior open bite, lateral open bite, crowding, occlusion, lingual posterior crossbite, buccal posterior crossbite, cephalometrics, and other. Posttreatment records were evaluated in 8 OGS categories: alignment, marginal ridges, buccolingual inclination, occlusal contacts, occlusal relations, overjet, interproximal contacts, and root angulation. A case that loses $\leq$30 points received a passing grade for ABO phase III examination. The

Table 2. List of selected articles

Authors	Article	Journal	Year	Database
Djeu G, Shelton C, Maganzini A[8]	Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system	*Am J Orthod Dentofacial Orthop*. 2005;128:292–298	2005	PubMed
Fetouh O[9]	Comparison of treament outcome of Invisalign and traditional fixed orthodontics by model analysis using the American Board of Orthodontics objective grading system	Thesis submitted to Faculty of the Graduate School of the State University of New York at Buffalo	2008	ProQuest
Pavoni C, Lione R, Laganà G, Cozza P[10]	Self-ligating versus Invisalign: analysis of dentoalveolar effects.	*Ann Stomatol (Roma)*. 2011;2:23–27	2011	PubMed

Invisalign group lost 45.35 points, whereas the braces group lost 32.21 points, which means the braces group had better treatment results. Specifically, the braces group was better in correcting buccolingual inclination, occlusal contacts, occlusal relations, and overjet. Both groups received similar results in alignment, marginal ridges, interproximal contacts, and root angulation. Treatment durations were 1.4 years for Invisalign and 1.7 years for braces. A limitation of the study was that the Invisalign patients were the first ones successfully treated by the clinician, who had more experience with fixed orthodontic treatment.

Fetouh[9] designed a similar study with 67 patients (34 fixed, 33 Invisalign). Summary and comparison of 3 studies is shown in Table 3. Fetouh[9] used 3 categories (crowding, overbite, and overjet) to assess discrepancy index, and other categories were reported to be within normal ranges. Seven OGS criteria were graded on posttreatment models: alignment, marginal ridges, buccolingual inclination, occlusal contacts, occlusal relationships, overjet, and interproximal contacts. Mean points lost were 19.15 points for the Invisalign group and 25.5 points for the braces group, which indicates that the Invisalign group resulted in better treatment out-

Table 3. Summary and comparison of studies by Fetouh[9] and Djeu *et al.*[8]

	Fetouh[9]		Djeu *et al.*[8]	
No. of patients				
Invisilign	33		48	
Fixed	34		48	
Total	67		96	
Mean age (y)				
Invisilign	Not stated		33.6	
Fixed	(permanant dentition)		23.7	
Discrepancy index score				
Invisilign	2.91		18.67	
Fixed	3.53		19.85	
Crowding	Mild		Moderate	
Points lost in objective grading system	Invisalign	Fixed	Invisalign	Fixed
Alignment	8.52	6.97	7.56	6.75
Marginal ridges	1.79*	3.56	4.90	4.44
Buccolingual inclination	0.76*	2.00	4.19	2.81*
Occlusal contacts	1.70*	4.74	10.46	5.65*
Occlusal relations	3.55	2.82	7.71	5.50*
Overjet	2.85*	5.41	6.21	3.56*
Interproximal contacts	0	0	0.77	0.65
Root angulation	Not included		3.56	2.85
Total	–19.15*	–25.50	–45.35	–32.21*

* $p < 0.05$.

comes overall. The Invisalign group performed better in marginal ridges, buccolingual inclination, overjet, and occlusal contact scores. Treatment durations were not stated. The study had the following limitations: panoramic radiographs were absent; root angulations were not evaluated, which might have been an advantage for Invisalign; and the fact that OGS does not measure overbite, which might also have been an advantage for Invisalign in the overjet correction score.

Pavoni *et al.*[10] designed a study that aimed to evaluate and compare changes in transverse dimension and maxillary arch perimeter produced by self-ligating braces (SLB; mean age 15.5 year) and Invisalign (mean age 18.25 year). Both groups consisted of 20 patients with permanent dentition and mild crowding. Mean treatment duration for both groups was 1.8 years. Dentoalveolar measurements were made on pretreatment and posttreatment maxillary dental casts. They measured intercanine width from cusp tip and from lingual surface, first premolar width, second premolar width, intermolar width from lingual surface and from central fossa, arch depth, and arch perimeter. They found that the increase in maxillary arch perimeter was significant with low-friction SLB. No difference in maxillary arch depth was found between the 2 groups. Treatment with SLB showed significant increase at the intercanine, first premolar, and second premolar widths.

DISCUSSION

The appropriateness and effectiveness of aligner systems remain a question among clinicians despite the instructive guidelines of manufacturers. The main purpose of this review was to search the literature to outline the efficiency, abilities, and limits of clear-aligner therapy in general, without focusing on a certain product. The keyword “clear aligner” was chosen for this purpose. In order not to overlook any studies with a certain type of aligner system, the keywords Invisalign, AsoAligner, and eCligner were also included in the search. The comparison intervention was set as “fixed orthodontic treatment,” which is the most widely studied subject in orthodontics and can be labeled the golden standard in this field.

In 2005, Lagravère *et al.*[11] published a systematic review focusing on the treatment effects of Invisalign orthodontic aligners. Unfortunately, the authors were unable to draw conclusions about indications, limitations, and outcomes of Invisalign because of the absence of randomized clinical trials to evaluate treatment effects.

Presently, studies about orthodontic treatment with clear aligners mainly investigate the Invisalign aligner technology. Of the 103 articles in PubMed database, 74 were published after 2005. Most of these articles are primarily descriptions of the system and case reports where investigators share their clinical experiences. Comparative studies that investigate treatment effects of aligners on patient comfort, periodontal health, material properties, activation sequence, and other aspects have also been studied. Studies that compare the outcomes of virtual model setups and the actual treatment with aligners are also present in the literature. Unfortunately, few clinical studies have assessed the effectiveness of the appliance compared with treatment effects of fixed orthodontic treatment.

The studies of Fetouh[8] and Djeu *et al.*[8] are comparable in design. However, the authors arrived at different conclusions on some aspects. Djeu *et al.*[8] found that the Invisalign group lost 13 points more, which suggests that treatment outcomes with braces are superior to those for the Invisalign group in patients with moderate crowding. The braces group scored more favorably in buccolingual inclination, occlusal contact, occlusal relation, and overjet assessment. One interesting result was that the aligner and braces groups had similar scores for the root angulation category. This may be due to the fact that most malocclusions start with relatively well aligned roots and that all patients in study had no extractions. Although aligner systems now claim that patients who have had extractions can be successfully treated with these appliances, some articles report unfavorable space closures and dental tipping.[12] Because the two groups also had similar scores for the alignment and marginal ridge categories, we believe aligner systems can provide good results in extraction treatments in carefully chosen cases, for example, where extraction is necessary to resolve crowding and there is not much retraction or posterior mesialization. On the other hand, Fetouh[9] concluded that the Invisalign group lost 6 points less on average than the braces group, which shows that treatment outcomes for the Invisalign group were better according to the ABO’s OGS index. The Invisalign group scored better in marginal ridges, occlusal contacts, buccolingual inclination, and overjet in patients with mild crowding.

The third study compared the effects of SLB and Invisalign on transversal arch dimensions. Com-

pared with conventional braces, SLB is claimed to facilitate more physiologic arch expansion.[13] Likewise, Pavoni *et al.*[10] found SLB to be more effective in arch expansion than Invisalign. However, this study compared the 2 systems only in one aspect—dental arch expansion—and does not provide us with other information.

CONCLUSION

Not enough studies are available to arrive on definite conclusions comparing clear aligner and fixed orthodontic treatment. If we derive common conclusions from the three studies in this review, in simpler cases, Invisalign may result in treatment outcomes as good as those of traditional orthodontic treatment, whereas fixed orthodontic treatment may be more beneficial for complex cases. However, it is obvious that more controlled clinical studies are necessary to define and support the abilities and limits of clear aligner therapy with evidence.

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