REVIEW ARTICLE

A Comparative Analysis between Orthodontic Treatment Outcome with Clear Aligners and Traditional Orthodontic Treatment

Abdulrahman Mislat Abdulrahman Almutairi[1]

1. *Ministry of Health, Eastern Health Cluster, Qarayat, AlUlya General Hospital, Saudi Arabia*

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ABSTRACT

In 1946 Kesling initially suggested the idea of transparent orthodontic equipment to straighten teeth. In 1998, Align Technology, Inc. introduced Invisalign®. The prevalence of clear aligners has significantly increased due to advancements in materials and computer-assisted orthodontic design. Numerous studies have proved the usefulness of clear aligners in correcting practically all malocclusions, from mild to severe, with great results.Aim of this research is to find and review the orthodontic literature evaluating the efficiency (treatment time, chair time), effectiveness (occlusal indices) and long-term stability of treatment with clear aligners as compared to traditional orthodontic therapy. After an initial screening phase 983 records were identified from the scientific databases, the potentially eligible 8 papers were qualitatively selected to evaluate the efficiency of clear aligners as compared to conventional orthodontic therapy.

KEYWORDS: Invisalign, clear alogner,orthodontic treatment

INTRODUCTION

The technology behind align has advanced significantly in recent years. Given the choice, many patients prefer clear aligners over traditional brackets due to their improved comfort and aesthetics, albeit their efficacy is still debatable. It was still unclear as to whether transparent aligners may be a good substitute for braces (1) In 1946 Kesling initially proposed the idea of clear orthodontic appliances to straighten teeth (2). In 1998, Align Technology, Inc. unveiled Invisalign®. The use of clear aligners has become much more common because of material progress and computer-aided tooth movement design. Numerous studies have demonstrated the efficiency of clear aligners in correcting almost all malocclusions, from mild to severe, with excellent results (3,4). While concerns about clear aligners replacing traditional orthodontics have grown in recent years as more and more patients seek an aesthetically pleasing and comfortable orthodontic treatment method, fixed braces have been the standard and most effective orthodontic equipment for more than a century. If transparent aligners are a good alternative to braces, that is still up for debate (5). Due to the lack of conclusive proof about the efficacy of the treatments, practitioners were forced to develop treatment regimens using only their own clinical expertise and subpar evidence.

AIM

The aim of this research is to identify and review the orthodontic literature regarding the efficiency (treatment time, chair time), effectiveness (occlusal indices) and long-term stability of treatment with clear aligners as compared to traditional orthodontic therapy.

MATERIALS AND METHOD

Data sources

Data extraction was carried out according to the standardCochrane systematic review methodology. Pubmed, Web of Science, Scopus, Medline, and Embase databases was searched from the year 1998 to 2023, for randomized clinical trials (RCT), controlled clinical trials (CCT) and cohort studies with keywords 'Invisalign' 'Orthodont' 'Fixed orthodontics.' After an initial selection phase 983 records were identified from the databases, the potentially eligible 8 articles were qualitatively selected to evaluate the efficiency of clear aligners and conventional orthodontic treatment.

A manual search of orthodontic journals including American Journal of Orthodontics and Dentofacial Orthopedics, European Journal of Orthodontics, Angle Orthodontist, Journal of Orthodontics and World Journal of Orthodontics was also performed.

Data extraction

Screening of eligible studies, assessment of the methodological quality and data extraction was conducted independently and in duplicate. Two reviewers evaluated the references using the same search strategy and then the same inclusion criteria to the selected studies were applied. PRISMA 2020 guidelines and flow diagram used to describe the selection process of searched articles.

The study was constructed on the PICO question as follows:
Population: Patients with dental malocclusion. Intervention: orthodontic treatment with clear aligners. Comparison: orthodontic treatment with fixed appliances. Outcomes: the primary outcome is treatment effectiveness: the outcome assessment of the treatment, includes arch width, occlusal contacts, alignment, derotation and inclination of teeth; the secondary outcome will be treatment duration. Study design: clinical comparative trials.

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	Inclusion criteria	Exclusion criteria
.	Clinical trials and randomized control studies	Systematic reviews or meta-analyses or expert opinions or narrative reviews
.	Published between 1998 and 2022	Out of the specified time range
.	English language of publication	Language other than English
.	In vivo (humans)	In vitro

Risk of bias assessment

Cochrane risk of bias assessment method was be used to assess the quality of the studies included.

Table 1. Patterns of force, engagement, and anchorage in fixed appliances versus clear aligners. [Courtesy of Caitlin Davis- Clear aligner technique- Bringing orthodontic treatment into the digital era. Quientessence publishing]

	FIXED APPLIANCES	CLEAR ALIGNERS
Force	Exerts a "pull" on teeth	Exerts a "push" on teeth
Engagement	Archwire into bracket: The thicker the wire, the better the engagement	Plastic around teeth: The more plastic wrapped around teeth, the better the engagement
Anchorage	Reciprocal anchorage: Newton's third law	Anchorage segments may be predetermined

Table 2. Capabilities of fixed appliances versus clear aligners in terms of extrusion, intrusion, and torque, and root inclinations. [Courtesy of Caitlin Davis- Clear aligner technique- Bringing orthodontic treatment into the digital era. Quientessence publishing]

	FIXED APPLIANCES	CLEAR ALIGNERS
Extrusion	Single tooth	Anterior segment
Intrusion	Relative intrusion only	Entire segments or selective intrusion
Torque	Labial and lingual root torque	Lingual root torque through power ridges
Root inclinations	Control of root inclinations through bracket positioning and archwire bends	Control of root inclinations through optimized attachments and virtual gable bends

Table 3. Capabilities of fixed applications versus clear aligners in terms of incisor inclination, vertical control, midline correction, and tooth size discrepancy. [Courtesy of Caitlin Davis- Clear aligner technique- Bringing orthodontic treatment into the digital era. Quientessence publishing]

	FIXED APPLIANCES	CLEAR ALIGNERS
Incisor inclination	Incisors tend to procline on alignment	Excellent control of incisor inclination
Vertical control	Overbite and overjet decreases with incisor proclination and alignment	Excellent vertical control in cases with minimal overbite and overjet
Midline correction	Dependent on elastic wear	Predictable
Tooth size discrepancy	Needs to be calculated or adjusted for midway through treatment	May be accurately calculated using ClinCheck software

DISCUSSION

Patients using transparent aligners reported improvements in comfort, convenience, and oral hygiene compared to those using standard fixed braces (6,7). However, not everyone was convinced that clear aligners were the best option for regulating tooth mobility (8). The effectiveness of transparent aligners as a treatment option, however, was not supported by many reliable studies when compared to that of traditional appliances. Because of this, treatment risks increased, and doctors had to rely more heavily on their experience. Lagravere in 2005, conducted a thorough review of the literature but was unable to locate any trials that evaluated the effectiveness of clear aligners as a treatment. (9) A 2015 systematic review found that transparent aligners effectively control anterior intrusion and posterior buccolingual inclination, but not anterior buccolingual inclination (10). Turning was the simplest action (with a 60% success rate), while extruding was the most challenging (with a 30% success rate). When the upper molar was distalized by no more than 1.5 mm physically, the highest degree of prediction (88%) was found. So, clear aligners were recommended for use in cases with mild misalignment (10). In 2014, Zeng et al. conducted a systematic review comparing clear aligners and braces, and they found only one relevant study. Clear aligners were shown to be less successful than braces, according to the authors (11). Clear aligners have been gaining popularity as an alternative to traditional braces, prompting the need for a thorough literature study to compare the two.

A meta-analysis of eight trials found that both clear aligners and braces are effective at addressing malocclusions, with braces showing a slightly higher likelihood of producing optimal results (12,13,14). When it comes to increasing transverse dento-alveolar width (15), a poor clinical outcome is associated with the inability to provide adequate occlusal contacts and the inability to manage posterior buccolingual inclination (16, 17). Clear aligners, on the other hand, maintained tooth inclination well during alignment without the need for extractions (18). Clear aligner patients experienced a greater relapse rate than braces patients (19).

Covering the occlusal surfaces of the teeth with aligners made it more difficult to extrude a tooth and stopped the occlusion from stabilizing. Since occlusal contacts are not as easily established by transparent aligners as they are by braces, this is the main reason why brackets and archwires were used to reposition the teeth and gently twist the roots to realign the bite and lengthen the arch. With removable clear aligners, patients and therapists must work together to ensure treatment is completed. To achieve the desired results was challenging.

Brackets, on the other hand, exert a coronal and buccal force right at the teeth's weakest spot (20). This could cause the item to tip or procline as it is being aligned. Straightening teeth with transparent aligners is possible, either with individual aligners for each tooth or with a series of aligners. This gradual, sectioned action is effective in reducing the degree to which teeth procline. Some studies have found that patients with thin gingival biotypes benefit from utilizing transparent aligners because they lessen the chances of recession.

Therapy using clear aligners was shown to be more efficient than treatment with braces when viewed from a time standpoint in a meta-analysis. Clear aligners were reported to be superior to braces in terms of both chair time and overall treatment time by Ke et al (21). No extractions were performed on any of the patients who were potentially eligible for inclusion in the meta-analysis. Clear aligners lengthened treatment duration for extraction patients by 44%, according to research by Li et al. (22)

A meta-analysis found that therapy using clear aligners is more efficient than treatment with braces in terms of time. Clear aligners were reported to be superior to braces in terms of both chair time and overall treatment duration by Ke et al. [21]. No extractions were performed on any of the patients who were potentially eligible for inclusion in the meta-analysis. Using clear aligners for extraction cases, as found by Li et al. [22], lengthens the treatment time by 44% compared to using braces.

Table 4**:** Summarized data of the 8 included studies

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Literature	Research Design	Research purpose	Subject	Result	Conclusions
Christou T (2019)	Case-control study	To evaluate and compare smile treatment outcomes between patients treated with Invisalign clear aligners (Align Technology, Santa Clara, Calif) and those treated with traditional fixed appliances by integrating variables such as lip symmetry, smile index, smile cant, buccal corridors, and gingival display into smile outcome evaluation.	Records from 58 patients, 29 of whom received Invisalign treatment (mean age 19.03 years) and 29 of whom received traditional fixed-appliance treatment (mean age 13.83 years), were compared for their smile outcome. Pretreatment scores, posttreatment scores, and differences between within-group smile score before and after treatment were determined for each group.	Six variables within the fixed-appliance group presented with better smile scores than those within the Invisalign group; buccal corridors (%) (mean difference = 8.42%), buccal corridors (mm) (5.35 mm), smile cant (0.42°), maxillary dental midline (0.21 mm), gingival display (0.56 mm), and smile index (1.09%) for P <0.05. Invisalign performed better on 2 variables that determined maxillary incisor position (1.26 mm) and inclination (2.09°). No significant difference (for P = 0.05) was shown between pretreatment and posttreatment scores for either of the 2 groups.	For patients with Class I nonextraction, treatment with traditional fixed appliances changes the patient's smile more than Invisalign treatment, and fixed appliances appear to be more effective in improving the variables that quantify posttreatment smile outcome.
Albhaisi Z (2020)	Randomized clinical trial	To investigate the relationship between clear aligner (CA) therapy and the development of white spot lesions and compare it with orthodontic fixed appliance (FA) therapy.	A total of 49 patients (39 female, 10 male; mean age ± standard deviation, 21.25 ± 3 years) who required orthodontic treatment with either FAs or CAs were randomly allocated into 1 of 2 study groups. Eligibility criteria included healthy patients of both sexes (age range 17-24 years), Class I malocclusion with mild-to-moderate crowding (≤5 mm), nonextraction treatment plan, and optimum oral hygiene before treatment as determined by clinical examination.Quantitative light-induced fluorescence (QLF) images were taken before treatment (T0) and 3 months later (T1). The QLF images were then analyzed to assess the research outcomes. The main outcome was the mean amount of fluorescence loss (ΔF). Number of newly developed lesions, deepest point in the lesion (ΔFMax), lesion area (pixels), and plaque surface area (ΔR30) were measured as secondary outcomes.	In total, 42 of the 49 participants recruited completed the study (19 in the CA group and 23 in the FA group). The mean amount of fluorescence loss was 0.4% for the CA group (P = 0.283) and 1.2% for the FA group (P = 0.013). The difference between the 2 groups was significant (confidence interval [CI], -1.8 to -0.4; P = 0.002). The mean increase in lesion area was 82.2 pixels for the CA group (P <0.001) and 9.3 pixels for the FA group (P = 0.225). The difference between the 2 groups was significant (CI, -117 to -75.0; P <0.001). ΔR30 was 1.2% for the CA group and 10.9% for the FA group (CI, 6.847-12.479; P <0.001). The number of newly developed lesions in the CA group was 6 lesions/patient and 8.25 in the FA group (P = 0.039).	Orthodontic treatment with CAs and FAs caused enamel demineralization. The CA group developed larger but shallower white spot lesions, whereas the FA group developed more new lesions with greater severity, but they were smaller in area.
Lanteri V (2018)	Retrospective study	To determine the efficacy of Invisalign in a large sample of patients compared to fixed appliances.	The test group consisted of 100 patients treated with Invisalign compared with a control group treated with conventional fixed appliances matched for sex, age, and initial severity of malocclusion based on the amount of anterior dental crowding (Little Index) and the Peer Assessment Rating (PAR Index) scores.A paired t test was used to compare both initial and final PAR scores.	There was an overall 80.9% improvement, and 63 subjects did not need any refinement. The mean number of aligners used was 14 (+ 15 for the refinements) in the maxillary arch and 29 (+ 14 for the refinements) in the mandibular arch. The mean duration of treatment was 14 months (+ 7 months for the refinements). Significant statistical differences were found in the posttreatment scores, within both the Invisalign group and the control group. No differences were found in the follow-up scores. Additionally, the duration of treatment was 4 months longer in the control group.	More than 90% of the subjects treated with Invisalign achieved a significant improvement, as shown by the PAR scores. A need for additional aligners was reported for 37% of the patients. Fixed bonded retainers seem to be a good option in preventing tooth relapse after Invisalign and fixed conventional treatments.
Gu J (2016)	Retrospective case-control study	To compare the treatment effectiveness and efficiency of the Invisalign system with conventional fixed appliances in treating orthodontic patients with mild to moderate malocclusion in a graduate orthodontic clinic.	Using the peer assessment rating (PAR) index, we evaluated pretreatment and posttreatment records of 48 Invisalign patients and 48 fixed appliances patients. The 2 groups of patients were controlled for general characteristics and initial severity of malocclusion. We analyzed treatment outcome, duration, and improvement between the Invisalign and fixed appliances groups.	The average pretreatment PAR scores were 20.81 for Invisalign and 22.79 for fixed appliances (P = 1.0000). Posttreatment weighted PAR scores between Invisalign and fixed appliances were not statistically different (P = 0.7420). On average, the Invisalign patients finished 5.7 months faster than did those with fixed appliances (P = 0.0040). The weighted PAR score reduction with treatment was not statistically different between the Invisalign and fixed appliances groups (P = 0.4573). All patients in both groups had more than a 30% reduction in the PAR scores. Logistic regression analysis indicated that the odds of achieving "great improvement" in the Invisalign group were 0.329 times the odds of achieving "great improvement" in the fixed appliances group after controlling for age (P = 0.0150).	Our data showed that both Invisalign and fixed appliances were able to improve the malocclusion. Invisalign patients finished treatment faster than did those with fixed appliances. However, it appears that Invisalign may not be as effective as fixed appliances in achieving "great improvement" in a malocclusion. This study might help clinicians to determine appropriate patients for Invisalign treatment.

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Azaripour A (2015)	Cross-sectional study	Evaluated oral hygiene and patient's satisfaction during orthodontic treatment of patients with FOA or Invisalign®.	100 patients (FOA = 50, Invisalign® = 50) were included who underwent orthodontic treatment for more than 6 months. Clinical examinations were performed to evaluate patients' periodontal condition and were compared with clinical data at the beginning of the orthodontic treatment. Oral hygiene, patients' satisfaction and dietary habits were documented by a detailed questionnaire.	Patients with FOA were in orthodontic therapy for 12.9 ± 7.2 months, whereas patients with Invisalign® were in orthodontic therapy for 12.6 ± 7.4 months. Significantly better gingival health conditions were recorded in Invisalign® patients (GI: 0.54 ± 0.50 for FOA versus 0.35 ± 0.34 for Invisalign®; SBI: 15.2 ± 7.6 for FOA versus 7.6 ± 4.1 for Invisalign®), whereas the amount of dental plaque was also less but not significantly different (API: 37.7 % ± 21.9 for FOA versus 27.8 % ± 24.6 for Invisalign®). The evaluation of the questionnaire showed greater patients' satisfaction in patients treated with Invisalign® than with FOA.	Patients treated with Invisalign® have a better periodontal health and greater satisfaction during orthodontic treatment than patients treated with FOA.
Fujiyama K (2014)	——-	To evaluate and compare the difference in the level of pain using the visual analog scale (VAS) between cases treated with the edgewise appliance and Invisalign. In addition, the cause of pain and discomfort in the Invisalign cases was identified.	The sample consisted of 145 cases for the edgewise group (EG; n=55), Invisalign group (IG; n=38), and edgewise and Invisalign group (EIG; n=52). VAS scores were collected during the first three stages (first stage: 0 to 7 days, second stage: 14 to 21 days, and third stage: 28 to 35 days) and at the end of the treatment (overall VAS score). Evaluation of the cause of pain was categorized into three different types of problem (category 1: non-smoothed marginal ridge or missing materials, category 2: deformation of attachments, and Category 3: deformation of the tray).	A significantly higher VAS score was observed at 3 and 4 days after, at 1, 2, and 3 days after, and at 2 and 3 days after in stages 1, 2, and 3, respectively, in EG compared to EIG and IG. A significant difference was observed in overall VAS scores between EG and IG in intensity of pain, number of days that pain lasted, and discomfort level. Only intensity of pain resulted in a significant difference between EG and EIG. Most of the causes of problem in the Invisalign cases were deformation of the tray.	Invisalign may offer less pain compared to the edgewise appliance during the initial stages of treatment. In the use of Invisalign, deformation of tray must be carefully checked to avoid pain and discomfort for the patients.
Pavoni C (2011)	Case-control study	To evaluate the changes in the transverse dimension and the perimeter of the maxillary arch produced by low friction self-ligating brackets TIME 3 compared to the Invisalign technique.	Both the self-ligating sample and the Invisalign group were composed of 20 subjects, evaluated at the beginning (T0) and at the completion of therapy (T1). All subjects presented a Class I malocclusion with mild crowding in a permanent dentition, without craniofacial anomalies, missing teeth or a history of orthodontic treatment. Dento-alveolar measurements were made on the maxillary dental casts at T0 and T1. Significant differences between the treated groups were assessed with Independent Samples t test ($p<0.05$).	Statistically significant differences between self-ligating sample and Invisalign group were recorded for CWC, FPWF, FPWL, SPWF, SPWL, and AP measurements. No significant changes were found for CWL, MWF, MWL, and AD values. There was not a statistically significant difference between the treatment durations of the groups: 1.8 years for both patients. These data suggest that Invisalign treatment cannot be somewhat faster than fixed appliances. Moreover the final occlusion might not be as ideal.	The low fiction self-ligating system produced statistically significant different outcomes in the transverse dento-alveolar width and the perimeter of the maxillary arch during treatment when compared to Invisalign tecnique.
Hennessy J (2016)	Randomized clinical trial	To compare the mandibular incisor proclination produced by fixed labial appliances and third generation clear aligners.	Patients underwent a course of orthodontic treatment using either fixed labial appliances or clear aligners (Invisalign). Mandibular incisor proclination was measured by comparing pretreatment and near-end treatment lateral cephalograms. Eligibility criteria included adult patients with mild mandibular incisor crowding (<4 mm) and Class I skeletal bases (ANB, 1-4°). The main outcome was the cephalometric change in mandibular incisor inclination to the mandibular plane at the end of treatment. Eligible patients picking a sealed opaque envelope, which indicated their group allocation, was used to achieve randomization. Data was analyzed using a Welch two-sample t-test.	Forty-four patients (mean age, 26.4 ± 7.7 years) were randomized in a 1:1 ratio to either the fixed labial appliance or the clear aligner group. Baseline characteristics were similar for both groups: Fixed appliance mean crowding was 2.1 ± 1.3 mm vs clear aligner mean crowding, 2.5 ± 1.3 mm; pretreatment mean mandibular incisor inclination for the fixed appliance group was 90.8 ± 5.4° vs 91.6 ± 6.4° for the clear aligner group. Fixed appliances produced 5.3 ± 4.3° of mandibular incisor proclination. Clear aligners proclined the mandibular incisors by 3.4 ± 3.2°. The difference between the two groups was not statistically significant ($P > .05$).	There was no difference in the amount of mandibular incisor proclination produced by clear aligners and fixed labial appliances in mild crowding cases.

CONCLUSION

OGS scores improving similarly overall suggested that braces and clear aligners were equally successful in addressing malocclusion. Clear aligners offered the advantage of segmenting tooth movement and cutting treatment time. While aligners were less effective than braces at producing adequate occlusal contacts, controlling tooth torque, increasing transverse width, and retaining improvements, they were more effective overall. Therefore, when making treatment decisions, physicians should consider the characteristics of these two orthodontic appliances.

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