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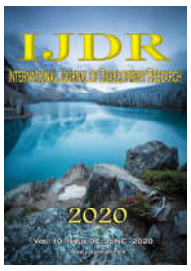

RESEARCH ARTICLE OPEN ACCESS

EFFECTIVENESS OF ALIGNERS IN ORTHODONTIC TREATMENT: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction Aligners are becoming widely used and very common in orthodontics. They have been increasingly developing over the last decade in order to respond to the needs of orthodontists and different clinical cases. The aims of this systematic review of the literature are to assess the aligner efficiency and to compare them to the fixed orthodontic techniques. **Materials and methods**: A broad search of MedLinePubmed, Cochrane, Scopus, Web of Science, Ebscohost and Science direct databases was conducted using the terms relevant to the subject.**Results**: Twenty-one papers were selected and were judged to be eligible for the present systematic review. The results involved tooth movement technique in 9 papers, aligners' efficiency in nine studies; and compared aligners to braces through three studies. **Conclusion**: Orthodontic aligners are nowadays considered a reliable and aesthetic alternative that have enlarged the arsenals of tools available for the orthodontist. Since their main treatment goals are mostly achieved, aligners have been judged to be sufficiently efficient and effective. Nevertheless, future studies are required to better understand their principles and for a greater control of the tooth movements.

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INTRODUCTION

Aligners, very commonly used nowadays in orthodontics, have not always looked as we know them now. It took almost a hundred years to create, modify and get to the modern aligners we know these days[1]. In 1999, Align Technology introduced Invisalign® as the pioneer aligner system in orthodontic treatment[21]. Since then, aligner therapy has experienced significant expansion worldwide and increasing diffusion in popularity. This growing is probably relies on some advantages linked to being aesthetic, offering greater comfort for the patient, and improved oral hygiene and periodontal health compared to fixed appliances thanks to their removability[3]. Growing demand led systematically to the improvement of the technique extending their indications from simple crowding cases to more complex malocclusion. This concept has deeply changed orthodontics, allowing adult patients with particular professional and social needs of the show business professionals who have constant contact with the public, adults who are experiencing late crowding or relapse after a conventional orthodontic treatment, and even adolescents concerned with their appearance to undertake treatment at any time [19,6]. However, the efficacy of the aligners in achieving complicated tooth movements is not elucidated in tangible way. The aims of work were firstly toevaluate the forces and moments delivered by different type of aligners and then to compare their movement concepts, results and efficiency with fixed appliances.

MATERIALS AND METHODS

The working group is composed of:

- An associate professor in orthodontics (I D).
- A thesis candidate in dentistry (N K).

Both members of the working group contributed to the review by the critical reading of articles, the extraction and synthesis of data, and the comparison of the different conclusions independently. In case of disagreement, a discussion between the work team members was planned over several meetings and through email conversations. The first step of an evidence-based process is formulating an answerable question. According to the preferred reporting items for systematic reviews and meta-analyses guidelines (PRISMA) [5], an

accurate well-conducted systematic review needs a structured format to improve its scientific credibility. Therefore, an accurate question was formulated conforming to the PICOS system standing for population, intervention, comparator, outcomes and study design whichfor this systematic review were defined as follows:

Population: teeth having undergone orthodontic therapies.

Intervention: orthodontic treatment with aligners.

Comparison: The comparators were teeth, which did not receive orthodontic forces and in a second time teeth having received conventional orthodontic treatment.

Outcome: Teeth reaction to orthodontic forces (the movement efficiency).

Study design*:* Meta-analysis, systematic reviews, randomized controlled trial, case-control studies, retrospective and prospective cohorts were preferred when available.

Bibliographic search

According to the (NAM) National Academy of Medicine's guide titled: "Finding What Works in Health Care: Standards for Systematic Reviews" the search strategy encompasses all measures taken to detect literature relevant to answer the research question and is thereby very critical to the success of the review and the validity of its findings[7]. Until June 2019, an electronic systematic search in the medical literaturewas performed to collect all papers potentially relevant to our review's question. It was restricted by language, leaving only English and French speaking articles, and was limited to human studies.

It went through the following electronic databases:

-MEDLINE via PubMed.
- Cochrane Library (CENTRAL)
- Web of science.
- Scopus.
- Science direct
-EBSCOhost

Keywords used in search included: "aligner", "orthodontics", "tooth movement" and "braces".

The following search strategies were developed for each database searched using Boolean formulas:

Boolean formula #1: "orthodontics" AND "aligner"

Boolean formula #2: "orthodontic aligner" AND "tooth movement"

Boolean formula #3: "aligner" AND "braces"

Articles selection process

Eligibility criteria: The inclusion and exclusion criteria for admittance in the systematic review are presented in (Table 1).

Critical reading of the selected articles: Thomson Reuters EndNote X8.2 was used for importing all the research results, discarding duplicates searching for available pdfs and later for managing bibliographies and citations.

Table 1. Inclusion and exclusion criteria of our study

Inclusion criteria	Exclusion criteria
Study design: Meta-analysis, systematic reviews, randomized controlled trials, case-control studies, cohort studies.	Study design: Narrative reviews, case report, case series, in vitro research reports, letters to the editors, commentaries, books, conferences.
Participants: Teeth that underwent orthodontic treatments	Participants: Animal studies Studies with fewer than 10 patients
Interventions: Treatment involving aligners or conventional brackets	Articles that do not meet the purpose of the review
Outcome: Teeth reaction to the treatment related to both aligners and conventional brackets	Articles with poor insufficientabstract data and whose full text was not available Articles that are in languages other than English and French

For studies appearing to meet approximately the inclusion criteria, for which we couldn't judge from the title and/or the abstract, the full paper was looked for and read when available. Relevance of found articles was assessed in a three-step process based on Bettany-Saltikov (2010)[4]:

Step1: Title screening looking for potentially eligible studies was performed to eliminate obviously unrelated papers (Pre-selection).

Step 2: Consisted in reading the abstracts of the pre-selected articles, to exclude all irrelevant references and to select likely relevant articles for final full text retrieval.

Step 3: consisted in obtaining the missing full texts of the remaining selected articles, then reading the article as a whole with final evaluation against the selection criteria for in- and exclusion

Level of evidence and quality assessment: Articles can be classified according to the level of scientific evidence based on the criteria of the Oxford Center for Evidence-based Medicine[14]. It defines 10 levels of evidence that are summarized in the following table where we only exhibit therapy studies levels (Table 2).

Table 2. Oxford Centre for Evidence-based Medicine – Levels of Evidence[7]

Level	Therapy / Prevention, Aetiology / Harm
1a:	Systematic reviews (with homogeneity) of randomized controlled trials
1b:	Individual randomized controlled trials (with narrow confidence interval)
1c:	All or none randomized controlled trials
2a:	Systematic reviews (with homogeneity) of cohort studies
2b:	Individual cohort study or low quality randomized controlled trials (e.g. <80% follow-up)
2c:	"Outcomes" Research; ecological studies
3a:	Systematic review (with homogeneity) of case-control studies
3b:	Individual case-control study
4:	Case-series (and poor quality cohort and case-control studies)
5:	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles"

Risk of bias: According to the CRD (Centre for Reviews and Dissemination, University of York) and to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statements, evaluation of methodological quality gives an indication of the strength of evidence provided by the study because flaws in the design or in the conduction of a study can result in biases [12, 2]. For this review, we used the "Newcastle Ottawa Scale" (NOS) for the assessment of the included studies.[11]. It is a method developed by the University of Newcastle, Australia in collaboration with the University of Ottawa, Canada. This tool is used to assess

the quality of studies included in a systematic review andmeta-analyses.

RESULTS

The global outcome of the electronic and manual searches as well as the articles selection process are illustrated in the PRISMA Flow Diagram in accordance with the PRISMA guidelines[12]. The literature research initially yielded a total of 828 references, many of them were iterative from one Boolean formula to another. This high amount of duplicates, is also due to the fact that several different databases were used. After removing duplicates only 282 articles remained. The titles screening process resulted in excluding 86 references leaving just 196. After reading through the abstracts of the remaining articles, only 77 were deemed useful and so made it to the last phase: reading the full texts if available and assessing their correspondence to the intended topic. Only 61 full texts were available. The reading led to the exclusion of 38 of them because they were not meeting our objectives either due to inappropriate study design such as case reports, in vitro studies and finite element analysis or just because they didn't answer the review's questions. At the end, we were left with a batch of 21 final papers that were included in the review. (figure 1)**.** Sample size in individual studies ranged from 16 to 480 subjects with a total of 1948 patients. Mean age at the start of the treatment in the evaluated samples ranged from 13 to 72 years.

Among the 21 included papers, two were classified as level A according to the Oxford Centre for Evidence-Based Medicine criteria. Nineteen studies were judged as B evidence level. Thus, conclusions with a considerable level of evidence could be drawn from the review process. The most recurrent tooth movements that were mostly discussed are molar distalization and canine rotation. Aligner therapy, when associated with composite attachments and class II elastics, can distalize maxillary molar efficiently by 2,6mm on average (between 1,5 and 3,9mm according to clincheck data) without significant tipping and vertical movements of the crown [17]. However, torquing movement was the most controversial. Some aligner systems revealed inability to fully achieve adequate rotation movements and sometimes showed problems with torque information correction[14]. In 2014, Simon and al showed that bodily tooth movements such as molar distalization, incisor torque, as well as premolar derotation can be accomplished using the Invisalign® system[17]. In fact, dental alignment and arch coordination at the end of treatment were comparable to the predicted results during the planning phase with different aligners software and patients referred a high level of satisfaction[13].

DISCUSSION

In this systematic review, we aimed to provide data on the efficiency, effectiveness and stability of treatment with aligners compared to conventional brackets. We hoped to give clinicians a better understanding of how well aligners work. The search strategy retrieves the totality of the studies that will be assessed for eligibility and inclusion. A well-constructed search strategy is thereby the core of the systematic review and it directly affects the quality of the results of our study. A limitation of some of the included studies - which might by extension be then a limitation to ours - is the lack of precision especially when using lateral cephalometric radiographs as a comparison tool. Baumrind and Frantz described the problems with using cephalometrics to assess angulations. They noted that the mandibular incisor apex, in particular, can be very difficult to locate. But in many studies each measurement was repeated a few times which minimizes the risks. The authors also mentioned that the results of their review should be interpreted with caution because of the number, quality, and heterogeneity of the studies. In another study about the accuracy of anterior tooth movement using aligner[22], it was proven that treatment with clear aligner can achieve a crown deplacement only without any root movement. This is related to the tilting motion when appliances cause tooth deplacement. In fact, a study in 2017 demonstrated that there is no significant difference between predicted and achieved position of anterior tooth (anterior torque) [18].

Remaining in the same context, another study also investigating the accuracy of clear aligners in non-extraction cases showed that a significant differenceare proved between estimated and achieved movements for all teeth except canines, first premolar and maxillary lateral incisors. Usually, a more occlusalposition of anterior teeth was founded (referring to the predicted movements); an incomplete rotation of rounded teeth and an unaccomplished displacement of posterior teeth in all three planes. Nonetheless; these differences weren't statistically- significant. For those reasons, we can conclude that the efficiency of Invisalign aligner in non-extraction cases is proved (digital outcomes are achieved. More recently, in 2017, Lombardo and al published an article about the predictability of F22 aligners in displacement of teeth to their virtual position already planned [19]. Only three published systematic reviews were identified[10,16,23] These reviews only focused on treatment effects, indications and efficiency of aligner system. However, specific tooth movements and comparison with conventional brackets were also evaluated in our review. Gu and al found that both appliances were able to improve the malocclusion[9]. However, data 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.

This study showed that fixed appliances improved malocclusion more effectively than did Invisalign®. However, aligners are faster and have the shorter treatment duration. Grunheid and al [8] revealed that aligner therapy generally led to an increased inclination, in contrast to fixed appliance therapy, which led to more upright mandibular canines, with unchanged inter-canine distance. To summarize, some Recommendations are useful for clinicians. In fact orthodontists have to rely on their clinical experience, for the establishment of the right indication when using aligners. Braces are not to be systematically left behind in favour of aligners just because they are becoming more and more demanded by our patients. A good knowledge of dimensions in which the final tooth position is less consistent with the predicted position, enables clinicians to build necessary compensations into the virtual treatment plan. Therefore, and in order to reap the full benefits of aligners and to make them even more effective, we recommend clinicians to take advantage of attachments and auxiliaries in conjunction with aligners which can assist and enhance the movements (tipping, torqueing; rotations, extrusions).

Conclusion

Since their main treatment goals are mostly achieved, aligners have been judged sufficiently efficient and effective. Thus, they are being more commonly indicated and have recently become widely used. To obtain adequate dental alignment and arch coordination, it is mandatory to make a correct diagnosis and to choose a define treatment objective achievable with the biomechanics offered by aligners. More studies are needed to get deeper insights into the issue because a better understanding of how tooth movement is achieved may lead to treatments that are more efficient.

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