Dentika Dental Journal
Journal homepage: https://talenta.usu.ac.id/dentika

Aesthetic innovation in clear aligners for orthodontic treatment

Kenjo Tri Putro[1], Viona Benedicta[1], Eirin Natasha Hutahaean[1], Sondang Pintauli[*2]

[1]*Faculty of Dentistry, Universitas Sumatera Utara, Medan, 20155, Indonesia*
[2]*Department of Dental Public Health/Preventive Dentistry, Universitas Sumatera Utara, Medan, 20155, Indonesia*
[*]Corresponding Author: sondangp@yahoo.com

ARTICLE INFO

Article history:
Received 27 February 2025
Revised 15 May 2025
Accepted 7 July 2025
Available online July 2025

E-ISSN: 2615-854X
P-ISSN: 1693-671X

How to cite:
Kenjo TP, Viona B, Eirin NH, Sondang P. Aesthetic innovation in clear aligners for orthodontic treatment. Dentika Dental Journal. 2019 Apr 25;2(1):67-76

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International.
http://doi.org/10.32734/dentika.v28i1.20076

ABSTRACT

Clear aligners are gaining popularity as an alternative to conventional fixed orthodontic appliances in orthodontic treatment due to the aesthetic appeal and comfort. Therefore, this scoping review aimed to discuss the current state of aesthetical value, clinical efficacy, material, and limitations of clear aligners in orthodontic treatments compared to fixed orthodontic appliances. A systematic search was conducted across PubMed, ScienceDirect, EBSCOHost, and Google Scholar, resulting in 657 articles, and only 19 met the inclusion criteria for in-depth analysis. The result showed that clear aligners, particularly Invisalign, are effective for mild to moderate malocclusions, offering enhanced aesthetics and increased patient satisfaction. However, these appliances are less effective than traditional braces in achieving precise tooth movements, such as occlusal adjustments and torque control. Advances in aligner materials, such as improved elasticity and reduced biofilm accumulation showed great potential but are limited by the amount of study found. In addition to the aesthetical value, clear aligners provide better treatment outcomes than fixed orthodontic appliances depending on the complexity of the malocclusion being treated.

Keywords: Clear Aligner, Orthodontic Treatment, Dental Aesthetics, Material Innovation, Malocclusion

ABSTRAK

Clear aligner telah menjadi semakin populer sebagai alternatif dari alat ortodontik konvensional dalam perawatan ortodontik, terutama karena daya tarik estetika dan kenyamanannya. Tinjauan lingkup ini bertujuan untuk membahas kondisi terkini mengenai nilai estetika, efektivitas klinis, material, dan keterbatasan clear aligner dalam perawatan ortodontik dibandingkan dengan alat ortodontik konvensional. Pencarian literatur sistematis dilakukan melalui PubMed, ScienceDirect, EBSCOHost, dan Google Scholar, menghasilkan 657 artikel, dari mana 19 artikel memenuhi kriteria inklusi untuk analisis mendalam. Temuan menunjukkan bahwa clear aligner, khususnya Invisalign, efektif untuk maloklusi ringan hingga sedang, menawarkan peningkatan estetika dan kepuasan pasien. Namun, clear aligner kurang efektif dibandingkan kawat gigi tradisional dalam mencapai pergerakan gigi yang rumit dan memerlukan presisi, seperti penyesuaian oklusal dan kontrol torsi. Kemajuan dalam material aligner, seperti peningkatan elastisitas dan pengurangan akumulasi biofilm, menunjukkan potensi yang menjanjikan, meskipun terbatas pada jumlah studi yang ditemukan. Selain nilai estetika, clear aligner dapat memberikan hasil perawatan yang lebih baik dibandingkan alat ortodontik konvensional, yang dimana hal ini tergantung daripada kompleksitas maloklusi yang dirawat.

Kata Kunci: Clear Aligner, Perawatan Ortodontik, Estetika Gigi, Inovasi Material, Maloklusi

1. Introduction

Aesthetic appeal and beauty are important in self-fulfillment, personal growth, self-discovery, and total well-being. Furthermore, aesthetic appeal and beauty are considered correlating subjects, as humans often perceive symmetrical and proportionate features as beautiful. [1] The need for the aesthetic and beauty of self has been deeply embedded within the majority of the populace in the current society as a means to be loved and accepted, as well as to raise self-esteem. According to a previous study, the human face is commonly used as the subject of judgment to scale an individual's typical visual attractiveness. [2] This judgment accounted for different aspects of the facial features, especially oral aesthetics. On the topic of aesthetic care, the skin has a dermatologist, while the oral scope has an orthodontist. In dentistry, the third most common problem after dental caries and periodontal disease is malocclusion. [3] This condition refers to the misalignment of the teeth, which can lead to various issues, such as health risks, reduced quality of life, and negative effects on psychosocial behaviour which impacts self-esteem due to poor facial aesthetics. [4] Malocclusion is considered a hereditary disease and is an issue that still prevails in adults and children, often impacting self-esteem due to poor oral aesthetics. Despite its lasting effect on mental health and well-being, malocclusion is often disregarded or ignored. This may be attributed to the common perception of orthodontic treatment, which includes the use of steel wires and brackets that must be worn for extended periods, potentially appearing aesthetically unpleasing. Therefore, there is a need for an alternative solution in a non-extraction orthodontic treatment that is both effective and aesthetically pleasing compared to traditional metallic braces, and those made from ceramic, composite, and lingual orthodontics. [5]

Advancements in the technology of orthodontic departments to address the aesthetic needs of patients introduce clear aligners as an effective and aesthetically pleasing alternative in non-extraction orthodontic treatment, also known as Clear Aligner Therapy (CAT). These aligners are characterized and marketed as thin, transparent, and aesthetically pleasing alternatives manufactured using CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technology. The product allows for high levels of complexity as well as precision and comfort of the treatment compared to the highly visible traditional braces. [6] Therefore, this scoping review aimed to examine the current state regarding the aesthetical preference, clinical effectiveness, material, and limitations on clear aligners in orthodontic treatment, especially when compared to traditional metallic braces.

2. Materials and Methods

This scoping review aims to investigate the efficacy and aesthetical beauty of clear braces and aligners in orthodontics treatment. A literature search was conducted using various public databases available on the Internet, such as PubMed, ScienceDirect, EBSCOHost, and Google Scholar. Some of the keywords used are Aligner, Braces, Clear Aligner, Clear Braces, Aesthetic, Effectiveness, Orthodontic Treatment, Innovation, Comfort, Malocclusion, and CAT. Eligibility was based on the following criteria without restrictions on the year of publication: 1. Peer-reviewed articles, cross-sectional surveys, clinical trials, case reports, qualitative studies, and technology reports, excluding literature reviews related to orthodontic treatment, especially the effectiveness and aesthetics of clear aligners regarding the patient's satisfaction with the treatment. 2. Studies discussing new technologies, design innovations, and aesthetic aspects regarding clear aligners. 3. Studies that are written in English. 4. Studies that are consistent with the aim of the review, focusing on the current state of the effectiveness, aesthetics, comfort, and limitations of clear aligners on orthodontic treatment. 5. Studies that can be accessed as full-text

The literature search and data selection were carried out independently by 3 authors using separate databases. Duplicates were identified and removed, followed by the screening of irrelevant literature by an author. Full texts of the remaining studies were assessed for eligibility and those that passed this process were subsequently organized and used to construct this review.

2.1. Results

Data extracted from the selected articles were synthesized and reported in a narrative format. A thematic analysis method was used to identify common patterns and developing themes across the studies. Quantitative data, such as success rates and treatment durations regarding the topic were extracted where available and analyzed thematically, as shown in Figure 1.

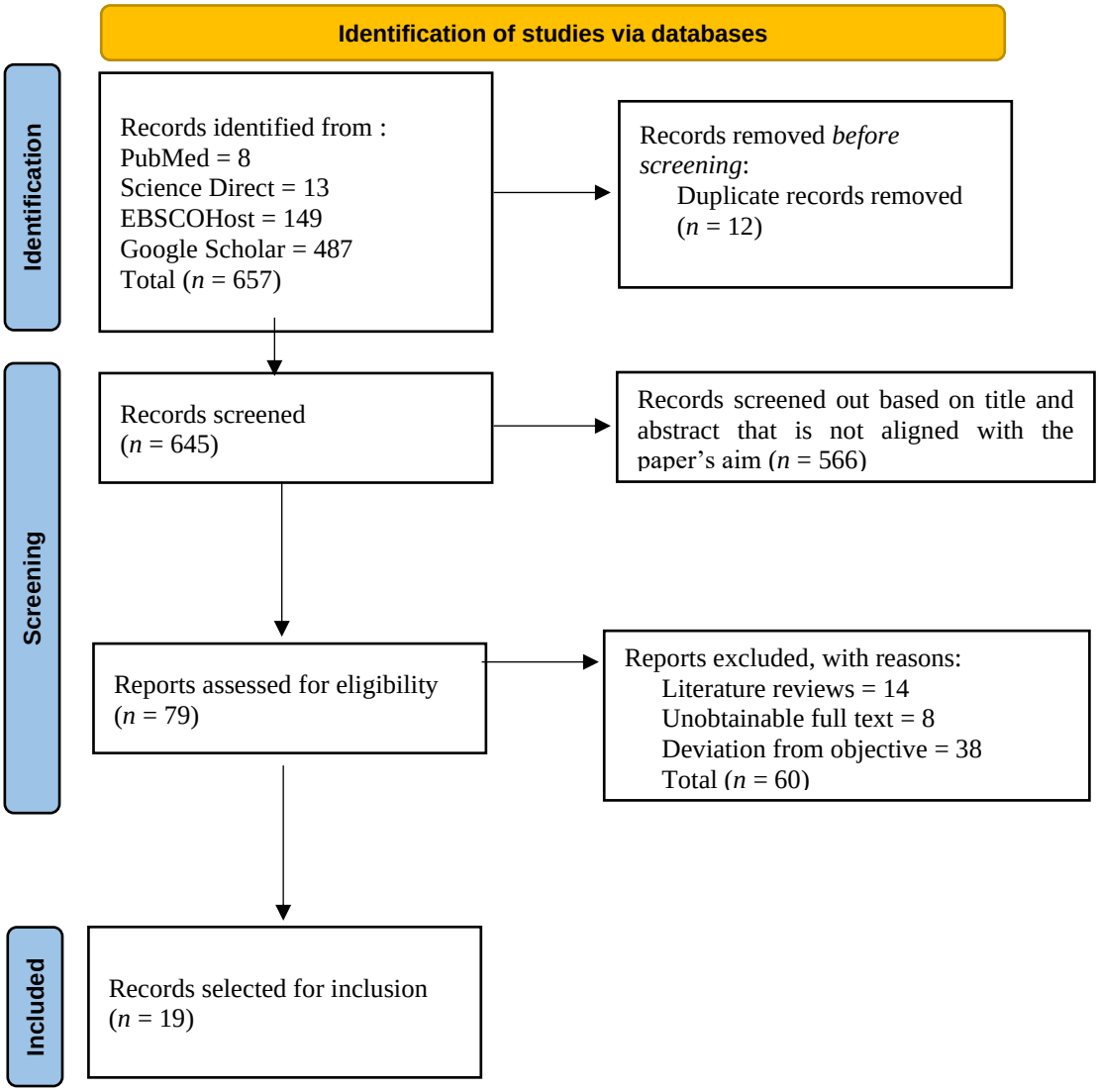

Figure 1. Flow Diagram

A collection of 657 articles was recorded based on the title and imported into BibTex format to be imported to Mendeley Reference Manager, then 12 duplicates were removed before screening. In the first stage of screening, 563 articles were considered unsuitable due to the title and abstract that were not consistent with the study's aim. From the initial number of 657 articles, 79 were considered potentially relevant and filtered using the eligibility criteria. Finally, 19 articles were selected and organized into categories to be discussed, providing a comprehensive overview of the current state of the innovation in clear aligner technology, the preference or aesthetical value, materials, limitations, and its effectiveness in orthodontic treatment.

2.2. Study characteristics

All the studies that were included were published in the past 10 years, and the majority were systematic reviews (42%). These were followed by cohort studies (21%), cross-sectional surveys (16%), in vitro (11%), case reports (5%), and case series studies (5%). The information on the studies included were categorized into 3 tables in correlation to content, namely effectiveness (Table 1), materials (Table 2), and aesthetical value (Table 3) of clear aligners. The majority of the studies include the use of Invisalign brand clear aligners.

Table 1. An overview of included studies providing information on the efficacy of clear aligners

Authors	Study type	Sample size	Main results
Jaber ST et al. 2023 [7]	Systematic review	6 Studies	Clear Aligners have difficulty producing better results in extrusion movement, buccolingual inclination, and occlusal contact in contrast to conventional fixed orthodontic appliances. Although upon treatment in mild and moderate cases, clear aligners show potential as an effective solution.
Rossini G et al. 2014 [8]	Systematic review	11 Studies	Despite the small sample size, bias, and a lot of variables, the study concluded that CAT is an effective solution to align and level arches on non-growing patients.
Liu F et al. 2024 [9]	Cohort study	46 (18 Male/ 28 Female)	This study examined the effectiveness of clear aligners physically and psychologically in contrast to fixed orthodontic appliances. Clear aligners show enhanced results when compared with traditional fixed orthodontic appliances, such as improved treatment effect, periodontal condition, and comfortability.
Ke Y et al. 2019 [10]	Systematic review	8 Studies	Both clear aligners and braces effectively treated malocclusion. Clear aligners offered advantages in segmented tooth movement and reduced treatment time. However, these products were less effective than braces in achieving optimal occlusal contacts, controlling tooth torque, and ensuring retention.
Rawah T et al. 2022 [11]	Case report	1 Male	Effective results were found from orthodontic correction of Class II skeletal malocclusion complicated by deep bite by Invisalign using built-in mandibular advancement (MA) features with desired tooth movement predicted using Clincheck.
Oikonomou et al. 2021 [12]	Systematic review and meta-analysis	21 Studies	Usage of aligners on orthodontic treatments showed better oral health levels in the short term compared to fixed appliances despite very low certainty by evidence. These studies also discussed the performance of aligners when faced with achieving occlusal goals which is still possible but less effective compared to fixed orthodontic appliances.
Yang Y et al. 2023 [13]	Systematic review and meta-analysis	10 Studies	Analysis of 10 clinical trials, in which 4 included the measurement of pain levels, showed a noticeable decrease in pain scores in the usage of clear aligners. There was also a report of lower plaque accumulation in Invisalign usage compared to fixed orthodontic appliances.
Fujiyama K et al. 2014 [14]	Cohort study	145 (49 Male/145 Female)	A total of 145 samples were divided into 3 groups undergoing orthodontic treatment using a conventional edgewise appliance, clear aligner, and both combined. While the duration of pain is the same, the intensity between the clear aligner group and the others was quite significant, and the cause seemed to be caused by distortion of the tray in Invisalign.

Muro MP et al. 2023 [15]	Systematic review	33 Studies	Most studies included were using Invisalign with Clincheck as a prediction tool. In most cases, Clincheck predictability was overrated and not accurate although the precision of the prediction increased along with the treatment. Aligner treatment was effective for mild to moderate crowding resolution.
Macrì M et al. 2024 [16]	Comparative case series study	4 (3 Male/1 Female)	The sample size was divided into 2 groups, and each was treated with braces and clear aligners in association, with orthognathic surgery. Despite the limited sample size, clear aligners have similar successful outcomes when compared to fixed orthodontic appliances.
Graf et al. 2020 [17]	Cohort study	33 (9 Male/24 Female)	A reduction in the Peer Assessment Rating (PAR) score was observed, wherein cases related to stability and effectiveness were categorized as either "improved" or "greatly improved," with no instances recorded in the category of "worse or no different" following treatment with Invisalign.
Simon M et al. 2014 [18]	Cohort study	30 (11 Male/19 Female)	A 59% effectiveness was observed using Invisalign (2012, Exceed30 (EX30) version) and Clincheck on incisor torque, premolar derotation, and molar distalization. The result showed that Removable Thermoplastics Appliances (RTAs) are useful on more complex malocclusion issues.
Papadimitriou A et al. 2018 [19]	Systematic review	16 Studies	A comparison between the use of Invisalign and traditional braces showed that no clear recommendations can be made due to significant heterogeneity.

Table 2. An overview of included studies providing information regarding materials of clear aligners

Authors	Study type	Sample size	Main results
Alam MK et al. 2023 [20]	Systematic review and meta-analysis	16 Studies	Materials and attachments of clear aligner usage in orthodontic treatment need to be considered depending on the severity and complexity of malocclusions as it can also affect retention.
Alexandropoulos A. et al. 2015 [21]	In vitro study	32 specimens in total (8 from each group of 4)	A total of 8 specimens from 4 groups of clear aligners (A+, Clear Aligner, Essix ACE Plastic, and Invisalign) were analyzed in terms of material hardness, elasticity, and creep resistance. Invisalign was found to have the preferred amount of hardness and elasticity but less creep resistance compared to other groups.
Zhang M et al. 2020 [22]	In vitro study	-	Synthesis of biologically safe gold nanoparticle-coated Invisalign proved to be effective in preventing biofilm formation.

Table 3. An overview of included studies providing information in regards to the aesthetical value of clear aligners

Authors	Study type	Sample size	Main results
Nausheen A et al. 2024 [23]	Cross-sectional survey	95 (90 Male/105 Female)	A questionnaire was provided to all participants based on the attractiveness of 9 different orthodontic appliances. The appliances were scored using a Visual Analogue Scale scaled from 1-10, in which the results showed clear aligners and ceramic self-ligating brackets being preferred in contrast to other appliances due to clear materials and minimal visibility when compared.
Miranda e Paulo et al. 2024 [24]	Cross-sectional survey	60 Orthodontists (43 Male/17 Female)	Clear Aligner Therapy (CAT) has recently gained an increase in the number of treatments due to its aesthetic appeal. According to professional orthodontists, fixed orthodontic appliances have better responses due to case complexity, bias, and even saturation of online studies regarding the issue. Most orthodontists prescribed CAT, but the usage was determined depending on the severity or complexity of the malocclusion. Orthodontists who do not prescribe CAT believe that fixed appliance therapy had superior treatment outcomes.
Försch M et al, 2020 [25]	Cross-sectional survey	140 Participants	Lingual orthodontic does not affect the perception of the face, while a clear aligner with and without attachments showed a slight effect compared to ceramic brackets as the most visually impairing appliance.

2.3. Quality assessment regarding the included study

A total of 19 studies from the literature search were included for risk of bias analysis. In this case, modified criteria following the Bondemark scoring system were implemented during the analysis [26] and 9 studies were considered to have a low risk of bias [7,8,10,12-15,19,20] due to the provision of a clear and acceptable method with no interfering conflict of interest. Furthermore, 7 studies were found to be at moderate risk of bias [9,17,18,21-23,25] in correspondence to the type, data, sample size, and methods provided. In the high-risk category, 3 studies were found [11,16,24] due to classification and a minimal amount of samples. The cross-sectional survey included in this category was found to have a small percentage of response rate in the survey. [24]

2.4. Synthesis of studies

The results from multiple cross-sectional surveys with a total of 295 participants, provided sufficient evidence that clear aligners have undoubtedly established qualities in aesthetical value. This quality makes clear aligners preferable due to the transparent properties when compared to other options [23-25]. The result of this scoping review has also proven the significance of aesthetics and beauty in the consideration of patients in orthodontic treatment. Studies evaluating the effectiveness of clear aligners (Table 1) showed a range of results. A study mentioned that clear aligners are generally less effective than fixed orthodontic appliances in achieving occlusal goals [12]. A cross-sectional survey of orthodontists also showed that the usage of fixed orthodontic appliances in treatment has superior treatment outcomes despite not using clear aligners. [24] Meanwhile, most studies mentioned clear aligners as a comparable or even better option when treating mild to moderate issues on achieving occlusal goals, while simultaneously providing better comfortability, reduced pain levels, and time needed for treatment completion [7-10,13-15]. Some studies have reported the ability to treat more severe cases of malocclusion, but the data collected were characterized by a high risk of bias

[11,17,18]. Based on the evidence provided, it can be concluded that clear aligners have proven effective in addressing mild to moderate malocclusion issues.

Clear aligners may potentially serve as an effective adjunct or alternative to conventional orthodontic appliances in managing more advanced stages of malocclusion. However, due to the limited data available on the use for severe or complex cases, coupled with the high risk of bias, no definitive recommendations can be made. Further analysis of the literature showed that the materials and shapes affect the quality of treatment, as these actors impact the constancy of force and the stability of the structure. [15,20] Placing importance on the materials used in clear aligners is essential, as these not only diminish the quality of treatment but may also induce pain and discomfort. The primary source of pain associated with the use of clear aligners is tray distortion, which can be attributed to the mechanical properties of the materials employed. [14,15] An in-depth analysis of the material properties of varying clear aligners in the market was found. In this case, Invisalign was found to be of polyurethane-based materials otherwise marketed as SmartTrack, and also have the preferred amount of elasticity and hardness compared to other samples that used polyethylene and polypropylene. [21] From the analysis, the use of Invisalign in the studies collected was due to superiority in material composition, treatment predictability, and the addition of its signature software named ClinCheck which allows ease of treatment planning for orthodontists. The polyurethane-based SmartTrack material, unique to Invisalign, provided an optimal balance of elasticity and hardness, allowing for more consistent force application and greater structural stability.

Consequently, Invisalign has become a preferred choice, as this material allows for reliable and comparable data across studies. Orthodontic treatments are widely recognized as extensive and rigorous. The introduction of clear aligners offers a less restrictive alternative to fixed orthodontic appliances, as clear aligners are removable yet still necessitate 22 hours of daily usage. [27] A prevalent issue shared by all orthodontic appliances relates to oral hygiene and health, as these devices must be worn for extended periods. Despite clear aligners offering a distinct advantage over fixed appliances in terms of hygiene, these products still present the same risks. Because aligners must be worn for approximately 22 hours per day for the treatment to be effective, [12,27] prolonged exposure to the aligner trays can trap bacteria and create an environment conducive to biofilm and plaque accumulation when oral hygiene is not maintained rigorously. Analysis of the study results led to the conclusion that advances in the material manufacturing of clear aligners are necessary to enhance the quality of life and effectiveness of orthodontic treatment. Only 1 study was found in the literature search of this scoping review [22] which explored the incorporation of nanotechnology into clear aligners to provide better antimicrobial protection.

3. Discussion

The concept of clear aligners was first pioneered by Kesling in 1945 as a complementary orthodontic tool, followed by Ponitz which enhanced its mechanics but was still deemed ineffective and inaccurate in treating malocclusions. [15] Over the decades, advancements in technology have positioned clear aligners as a legitimate alternative to conventional fixed orthodontic appliances, especially for patients in need of aesthetically pleasing and comfortable treatment options. In contemporary times, clear aligners have become widely popular among adults, reflecting the growing emphasis on the need for beauty and aesthetics in society. [23,24] Despite this rising popularity, concerns remain regarding the efficacy, particularly in complex malocclusions and precision movements, such as extrusion movement, torque control, and occlusal movements, where conventional fixed orthodontic appliances have outperformed clear aligners. [10] Recent studies and developments have provided evidence that clear aligners can be effective in treating complex or severe malocclusion issues, albeit with varying degrees of success [11,17,18]. This suggests that the technology holds considerable promise in meeting both patient satisfaction and treatment efficacy requirements, potentially offering a viable alternative to conventional orthodontic appliances. A re-evaluation of the progress made by clear aligner technology is necessary due to ongoing concerns about its efficacy. Therefore, this scoping review aimed to summarize the current state of clear aligners, specifically their clinical efficacy, materials, and aesthetic value. While it can be considered that the amount of study included in this review was quite significant, there were no random clinical trials (RCTs) in the analysis. The majority of the included studies are systematic reviews [7,8,10,12,13,15,19,20] with a low risk of bias. The studies included in this review exhibited substantial heterogeneity in terms of methods, results, and sample size. However, the interventions employed across these studies were relatively consistent, with most using Invisalign. Furthermore, the predominant use of Invisalign, as evident from the data synthesis, was due to its superiority in different aspects over other brands. [21]

Figure 1.Clear Aligners Produced Utilizing CAD/CAM [28]

Clear aligners have been a popular choice among adults due to not affecting the aesthetical value of the face at all, as it is hardly noticeable. Data synthesized from the cross-sectional surveys included in this review showed the aesthetic value of clear aligners, attributed to transparent nature. Participants reported that the use of clear aligners was often barely noticeable to others. [23,25] Despite the aesthetical appeal and values of clear aligners, efficacy during treatment has been debated amongst experts throughout the years. These products have made significant strides in the ability to provide a viable, aesthetically pleasing alternative to conventional orthodontic appliances, particularly in the treatment of malocclusions. Many studies have proven its efficacy in regard to mild to moderate malocclusion cases, requiring less time and providing a better quality of life than conventional orthodontic appliances. [7-10,13-15] Some studies even found that clear aligners could treat severe or more complex malocclusions, [11,17,18] but with less efficacy than fixed orthodontic appliances. [18] A metric of the Peer Assessment Rating (PAR) Index were used in a previous study, [17] and clear aligners showed improved results on varying types of malocclusions from mild to severe cases, providing better stability and effectiveness within the treatment modality. [17] Despite these advantages, these products face limitations in terms of precision with certain tooth movements, such as extrusion, torque control, and achieving optimal results towards occlusal contacts, according to previous studies. [7,10,11] A study has shown that clear aligners are effective in achieving general alignment, but may be less effective than fixed orthodontic braces in cases requiring high-precision adjustments. Another study shows that factors influencing the efficacy of clear aligners differ from those of fixed orthodontic appliances, with efficacy depending on stability, flexibility, and force to induce orthodontic tooth movement, determined by the mechanical properties of the materials used in construction. [15,20] Most aligners use thermoplastic-based materials, which presumably provide the necessary mechanical properties needed for orthodontic treatments. [21] The effectiveness in complex or severe cases remains a topic of interest as some studies suggested that successful treatment of severe malocclusions is possible, either alone or in combination with other orthodontic interventions. [11,17,18] However, due to the limited scope, high risk of bias, and high heterogeneity, more comprehensive clinical trials are required to provide definitive recommendations for the use of clear aligners. The synthesis of studies included in this scoping review supported the view that clear aligners represent a significant advancement in orthodontics, combining aesthetic appeal with functional benefits. The ongoing innovations in material science and technology are expected to further expand the applications and effectiveness, potentially establishing clear aligners as a preferred treatment modality across a broader spectrum of orthodontic cases.

4. Conclusion

In conclusion, clear aligners served as an effective alternative to fixed orthodontic appliances, providing aesthetic appeal, comfort, and improved quality of life for patients who prioritized visual appearance. These products were effective and generally less time-consuming in treating mild to moderate malocclusions. However, limitations remain in managing complex tooth movements, such as occlusal precision, torque control, and retention, especially in extraction cases. Clear aligners were shown to treat severe malocclusions in some cases, although definitive conclusions were precluded by the limited number of studies and high risk of bias. Furthermore, clear aligners required strict adherence for treatment, with daily wear of 22 hours, which could lead to bacterial accumulation issues due to prolonged coverage of teeth and gingiva. The result of this scoping review showed that clear aligners were effective alternatives to fixed orthodontic appliances in treating less complex cases, and could even work as an assisting tool towards more complex cases. The products could also explore advancements in materials, such as nanoparticle infusions, as well as address concerns regarding

oral hygiene and further improve other aspects of the technology.

6. Acknowledgements

This review has received no external funding.

7. Conflicts of interest

All authors declare that there was no conflict of interest.

References

[1] Huang Y, Xue X, Spelke E, Huang L, Zheng W, Peng K. The aesthetic preference for symmetry dissociates from early-emerging attention to symmetry. Scientific Reports 2018; 8(1): 62-3.
[2] Luo Q, Yu M, Li Y, Mo L. The neural correlates of integrated aesthetics between moral and facial beauty. Scientific Reports 2019; 9(1): 19-80.
[3] Sharma S, Avasthi A, Kumar S, Singh N. Epidemiology of malocclusion: an Indian perspective-review article. Sch J Dent Sc 2019; 6: 142-7.
[4] Anthony SN, Zimba K, Subramanian B. Impact of malocclusions on the oral health-related quality of life of early adolescents in Ndola, Zambia. Int J Dent 2018; 2018 :1-8.
[5] Chandra A, Thosar NR, Parakh H. Clear aligners in pediatric dentistry: A scoping review. Cureus 2024; 16(4): 1-8.
[6] Weir T. Clear aligners in orthodontic treatment. Aust Dent J 2017; 62: 58-62.
[7] Jaber ST, Hajeer MY, Sultan K. Treatment effectiveness of clear aligners in correcting complicated and severe malocclusion cases compared to fixed orthodontic appliances: A systematic review. Cureus 2023; 15(4): 1-15.
[8] Rossini G, Parrini S, Castroflorio T, Deregibus A, Debernardi CL. Efficacy of clear aligners in controlling orthodontic tooth movement: a systematic review. Angle Orthod 2015; 85(5): 881-9.
[9] Liu F, Wang Y, Luopei D, Qu X, Liu L. Comparison of fixed braces and clear braces for malocclusion treatment. BMC Oral Health 2024; 24(1): 1-11.
[10] Ke Y, Zhu Y, Zhu M. A comparison of treatment effectiveness between clear aligner and fixed appliance therapies. BMC Oral Health 2019; 19(1): 1-10.
[11] Eshky RT. Orthodontic correction of class II skeletal malocclusion complicated by deep bite using clear aligners: A case report. J Taibah Univ Med Sci 2022; 17(6): 962-8.
[12] Oikonomou E, Foros P, Tagkli A, Rahiotis C, Eliades T, Koletsi D. Impact of aligners and fixed appliances on oral health during orthodontic treatment: A systematic review and meta-analysis. Oral Health Prev Dent 2021; 19: 659-72.
[13] Abusafia BM, Mohamed AMA, Al-Balaa M, Qiang QY, Abbas YS, Yang Y. Evaluation of gingival health and pain level in orthodontics treatment with clear aligners: A systematic review and meta-analysis. APOS Trends Orthod 2023; 13(4): 246-52.
[14] Fujiyama K, Honjo T, Suzuki M, Matsuoka S, Deguchi T. Analysis of pain level in cases treated with Invisalign aligner: Comparison with fixed edgewise appliance therapy. Prog Orthod 2014; 15(1): 1-7.
[15] Muro MP, Caracciolo ACA, Patel MP, Feres MFN, Roscoe MG. Effectiveness and predictability of treatment with clear orthodontic aligners: A scoping review. Int Orthod 2024; 21: 1 - 17.
[16] Macrì M, Alhotan A, Galluccio G, Barbato E, Festa F. Enhancing surgical outcomes via three-dimensional-assisted techniques combined with orthognathic treatment: A case series study of skeletal class III malocclusions. Appl Sci 2024; 14(8).
[17] Graf I, Puppe C, Schwarze J, Höfer K, Christ H, Braumann B. Evaluation of effectiveness and stability of aligner treatments using the peer assessment rating index. J Orofac Orthopedics 2021; 82(1): 23–31.
[18] Simon M, Keilig L, Schwarze J, Jung BA, Bourauel C. Treatment outcome and efficacy of an aligner technique - regarding incisor torque, premolar derotation and molar distalization. BMC Oral Health 2014; 14(1): 1 - 7.
[19] Papadimitriou A, Mousoulea S, Gkantidis N, Kloukos D. Clinical effectiveness of Invisalign® orthodontic treatment: A systematic review. Prog Orthodontics 2018; 19 (1); 37.
[20] Alam MK, Kanwal B, Shqaidef A, Alswairki HJ, Alfawzan AA, Alabdullatif AI, et al. A systematic review and network meta-analysis on the impact of various aligner materials and attachments on orthodontic tooth movement. J Funct Biomater 2023; 14(4): 209.
[21] Alexandropoulos A, al Jabbari YS, Zinelis S, Eliades T. Chemical and mechanical characteristics of

contemporary thermoplastic orthodontic materials. Aust Orthod J 2015; 31(2): 165 - 70.
[22] Zhang M, Liu X, Xie Y, Zhang Q, Zhang W, Jiang X, et al. Biological safe gold nanoparticle-modified dental aligner prevents the porphyromonas gingivalis biofilm formation. ACS Omega 2020; 5(30): 18685–92.
[23] Nausheen A, Hassan FU, Zadah S, Farid F, Ali MM, Kanju AH. Laypeople perception of attractiveness of the orthodontic appliances - a cross sectional survey. J Khyber Coll Dent 2024; 14(3): 46-50.
[24] Miranda e Paulo D, Moreira-Santos LF, Tavares MC, Weir T, Meade MJ, Flores-Mir C. Clear aligner therapy practices among orthodontists practicing in Canada. Prog Orthod 2024; 25(1): 1 - 8.
[25] Försch M, Krull L, Hechtner M, Rahimi R, Wriedt S, Wehrbein H, et al. Perception of esthetic orthodontic appliances: An eye tracking and cross-sectional study. Angle Orthod 2020; 90(1): 109–17.
[26] Bondemark L, Holm AK, Hansen K, Axelsson S, Mohlin B, Brattstrom V, Paulin G, Pietila T. Long-term stability of orthodontic treatment and patient satisfaction: A systematic review. Angle Orthod 2007; 77(1): 181–91.
[27] Al-Nadawi, M, Kravitz ND, Hansa I, Makki L, Ferguson DJ, Vaid NR. Effect of clear aligner wear protocol on the efficacy of tooth movement. Angle Orthod 2021; 91(2): 157–63.
[28] Cenzato N, Di Iasio G, Martìn Carreras-Presas, et al. Applrials for clear aligners—a comprehensive exploration of characteristics and innovations: a scoping review. Appl Sci 2024; 14(15): 1 – 14.