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RESEARCH ARTICLE

ALIGNERS IN PEDIATRIC DENTISTRY: A REVIEW

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Abstract

Aim and Background: Clear aligners are gaining popularity, particularly among adults, who often prefer them over traditional fixed appliances due to aesthetic concerns. This review explores the evolution of clear aligner technology, their benefits and drawbacks, limitations, patient comfort and acceptance, as well as their effectiveness in treating different types of malocclusions in comparison to braces.

Methods: Databases like Scopus, PubMed, and Google Scholar were employed to conduct a comprehensive literature search up until April 2024. The collected data was then systematically organized and integrated narratively to emphasize the main findings.

Results: The early literature revealed differing outcomes compared to more recent articles. This disparity was particularly evident in advancements in treating various malocclusions. Nevertheless, the findings indicate that aligners still lack the capability to achieve a wide range of movements in comparison to traditional braces.

Conclusion: Despite numerous claims, evidence supporting the effectiveness of clear aligners remains limited. Current research suggests that for mild to moderate cases, the primary advantages of transparent aligners over traditional systems are shorter treatment times and reduced chair time. Other reported benefits of clear aligner therapy include improved aesthetics, initial comfort, easier maintenance of oral hygiene, and better periodontal health.

Clinical Significance: According to the available evidence, clear aligner therapy is effective for treating minor malocclusions and yields satisfactory outcomes for moderate malocclusions.

Introduction:-

Orthodontic treatments have frequently been linked to the image of unattractive wires in the mouth. Moreover, people with metal braces were sometimes unjustly judged as less intelligent.[1]

Initially aligners were introduced to treat mild to moderate dental crowding and mild spacing [2], but now there are numerous literature and experts' experiences shown in more complex malocclusion cases which could be corrected with Clear Aligner Therapy. [3]

Primary dentition comes with its own complexities like deep overbite, spacing, and anterior cross-bite.Thilander B et al (1973) reported that 36% of the subjects with anterior cross-bite exhibit functional shifts.[4]If left untreated, an

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anterior crossbite can result in facial asymmetry, causing abnormal growth patterns where the development of the maxilla and dental structures may be restricted. Over time, this can lead to significant skeletal deformities, potentially resulting in aesthetic, functional, or social-psychological issues.[5]

Several methods have been employed to correct primary dentition, including removable transpalatal appliances with protruding finger springs, bonded resin-composite slopes, and selective grinding.[6,7] All the treatment approaches are favoured by clinicians due to their straightforward nature. However, they have inherent limitations regarding the extent of correction achievable.

Clear aligner treatment is patient-friendly, aesthetically appealing, and provides notable advantages over traditional appliances, particularly in terms of comfort and appearance. This makes it an ideal option for meeting the orthodontic needs of children.Early orthodontic treatment has its own benefits and limitations.

History:

In 1945, Harold D. Kesling introduced rubber-based tooth positioners crafted from wax setups of patients' teeth. Kesling's work pioneered key principles of modern clear aligner therapy (CAT), highlighting the potential of thermoplastic materials for significant orthodontic tooth movements.[8]In 1964, Nahoum introduced the dental contour appliance, which marked the first use of thermoformed plastic sheets for orthodontic tooth movement. In 1971, Ponitz developed an 'Invisible retainer' where Biocryl was used, which consist cellulose acetate butyrate, polyurethane (PU), polyvinyl acetate-polyethylene polymer, polycarbonate-cycolac, and latex.[9]Later,in 1993, the appliance was further modified and named the Essix appliance by Sheridan et al. In 1997, Zia Chishti and Kelsey Wirth, graduates of Stanford University, established Align Technology in San Jose, CA. They introduced a digitally designed clear aligner to the market, which they branded as Invisalign. In 2005, OrthoClear®, a competitor developed independently by Zia Chishti, co-founder of Align Technology, emerged in the market. Clear aligners, removable orthodontic appliances, have become increasingly popular in recent years for treating dental overlaps and misalignments.[1]

Materials used in clear aligners:

Polyethylene terephthalate glycol (PET-G) is widely recognized as the predominant material used in clear aligners. However, other materials such as polypropylene, polycarbonate, thermoplastic polyurethanes, and ethylene vinyl acetate are also utilized in the manufacturing of these orthodontic devices.[10] Table 1 below lists several popular clear aligner brands and specifies the materials used for fabricating the aligners.[11]

Code	Thickness	Product name	Manufacture	Component (MSDS)
EVA	1.0 mm	Bioplast	Scheu-Dental, GmbH	Ethylene-vinyl acetate copolymer
PE	1.0 mm	Copyplast	Scheu-Dental, GmbH	Polyethylene
PETG	1.0 mm	Duran	Scheu-Dental, GmbH	Polyethylene terephthalate glycol
PP	0.8 mm	Hardcast	Scheu-Dental, GmbH	Polypropylene
PC	0.75 mm	Imprelon "S"	Scheu-Dental, GmbH	Polycarbonate
A+	0.040 in.	Essix A+	Raintree Essix, Inc.	Copolyester
C+	0.040 in.	Essix C+	Raintree Essix, Inc.	Polypropylene/ ethylene copolymer (>95%), stabilizers (<5%)
PUR	0.030 in.	Invisalign	Align Technology, Inc.	Polyurethane from methylene diphenyl diisocyanate and 1,6-hexanedial, Additives

Component as obtained from the manufactures' material safety data sheet

Table 1:-Enlists popular clear aligner brands and the material used for aligner fabrication[11]

Indications-[12,13,14,15]
Malaligned problems (1-5mm) and mild crowding. Some slight lateral and/or antero-posterior expansionor some minor interproximal tooth reduction, or by removal of a lower incisor are some of the treatment options that can be done.
Spacing (1–5 mm)
Class II division 2 malocclusions related with deepbite where the overbite can be corrected by incisor intrusion and advancement.
Arches that are narrow and can be expanded without tipping the teeth.
Relapse cases after fixed orthodontic treatment.
Cases of minor rotations
Flaring of teeth
Distalization of teeth and space closure after lower incisor extraction.

Indications for CAT in mixed dentition:
Clear aligner therapy has appeared to be a viable option for treating mild to moderate malocclusions in children, addressing issues such as crowding, spacing, and minor corrections.Clear aligners not only offer functional advantages but also present a more discreet option compared to traditional braces, which is especially appealing to both children and parents concerned about the aesthetic aspects of orthodontic treatment. Their subtle appearance can boost a child's self-esteem throughout the process. Additionally, clear aligners can be utilized in early intervention during the mixed dentition phase, allowing for proactive management of orthodontic issues before they become more severe. Nevertheless, the success of clear aligner therapy in children largely depends on their commitment to wearing them as directed, underscoring the importance of adherence for achieving the best possible results.[1,16]

Various studies have showed the application of invisible aligners in pediatric patients. Some of them are listed below (Table 2):

Table2:-

Authors and year	Study	Conclusion
Abraham et al., 2016[17]	An innovative device known as "Modified clear tray aligners" was employed to correct the anterior crossbite in an 8-year-old child.	There has been a growing emphasis on the aesthetic appeal and practicality of orthodontic treatments, reflecting children's heightened awareness of how they look while wearing dental braces
Staderini et al., 2020[18]	Two 8-year-old children with an anterior crossbite were treated successfully with CAT, encountering minimal discomfort or issues, and achieved full resolution within five months.	This finding suggests that CAT (Computer-Aided Technology) could be particularly advantageous for aligning teeth that are in the process of growth and retain enough flexibility for orthodontic adjustments.
Levrini et al., 2021[19]	Twenty patients with an average age of 8.9 years received Invisalign® First treatment for maxillary expansion. The results showed notable increases in arch width and perimeter, while there were reductions in arch depth and molar inclination. Alveolar expansion was observed at all reference points.	The study indicates that Invisalign® First clear aligners could serve as a viable alternative to traditional expanders for treating mild crowding or limited transverse maxillary deficiency.
Zou et al., 2022[5]	A 4-year-old child with an anterior crossbite and facial asymmetry underwent CAT treatment for approximately 18 weeks.	The research demonstrated significant promise in early intervention for correcting misalignment issues in primary

		teeth.
Lombardo et al., 2023[20]	A total of 32 children received two distinct orthodontic expansion treatments for malocclusion correction: 17 children underwent rapid maxillary expansion, while 15 children were treated with clear aligners.	The study indicated that a clear aligner system was more effective than rapid maxillary expansion in controlling the angulation of upper first molars and increasing the palatal area. Additionally, the anterior segment of the arch could achieve greater expansion.
Lione et al., 2023[21]	A total of 23 subjects, with an average age of 9 years, were treated with Invisalign First System® clear aligners to evaluate the transverse development of the maxillary arch.	The Invisalign First System® proved effective for enhancing the development of maxillary arches in individuals. Significant improvements were observed primarily in the upper first deciduous molars, with noticeable rotational adjustments around the palatal root contributing to increased mesial breadth in the upper first molars.
da Silva et al., 2023[22]	A total of 32 patients, averaging 9.3 years old, received treatment with a 2x4 fixed appliance and clear aligners for approximately 8 months to correct irregularities in the position of maxillary incisors during mixed dentition.	Clear aligners and 2×4 mechanics demonstrated similar effectiveness and efficiency in aligning maxillary incisors during the mixed dentition phase.

Contraindications-[12,14]
Crowding and spacing (>5 mm).
Anterior-posterior skeletal differences (> 2 mm).
Sagittal discrepancies are measured in comparison to Class 1 canine relation.
Discrepancies between Centric-relation and centric-occlusion.
Teeth that have been severely rotated (greater than 20 degrees).
Anterior and posterior open bites that must be closed.
Teeth extrusion.
Teeth that are tipped (>45 degrees).
Teeth with clinical crowns that are too short.
Arches with a multiple missingtooth.

Advantages[23]
The trays are both aesthetic and comfortable since they are clear and do not contain metal brackets or wires that can cause mouth lacerations.
Clear aligners are virtually invisible, providing patients with the confidence to smile during their orthodontic treatment.
Clear aligners are technically much easier to manage than lingual appliances.
Compared to fixed braces clear aligners generally promote better oral hygiene
Clear aligners are ideal for retreatment
Requires shorter dental appointments.
Treatment duration is very much precisedthan braces
Creating Interdental space is created via interproximal reduction,avoiding extractions of premolars
Clear aligners reduce the need for frequent dental visits by enabling patients to replace their aligners independently every few weeks.

Disadvantages[24]
The absence of regular recall appointments makes the treatment largely dependent on the patient's compliance.

The success of the treatment relies heavily on the patient's motivation.

It is important to remove the appliance when consuming hot food or drinks, as heat can increase the likelihood of the appliance becoming deformed.

Although treatment time is typically pre-determined, patient non-compliance can hinder the achievement of desired results, and poor oral hygiene may further complicate the process.

Losing appliances can not only prolong the treatment duration but also lead to higher costs.

Biomechanics OF Cat[25,1]
The mechanism of tooth movement with clear aligners primarily revolves around two systems:

Displacement-driven system: Clear aligners focuses on controlled tipping and minor rotations of teeth by applying custom-designed aligners that gradually move teeth towards their desired positions in a treatment plan. This approach does not typically involve significant root movement, emphasizing controlled tooth displacement through sequential aligner stages.

Force-driven system:The force-driven system in clear aligner therapy leverages advanced technology to precisely plan and execute tooth movements using customized aligners. This approach ensures controlled and effective orthodontic treatment, tailored to the unique needs of each patient's dental alignment goals.

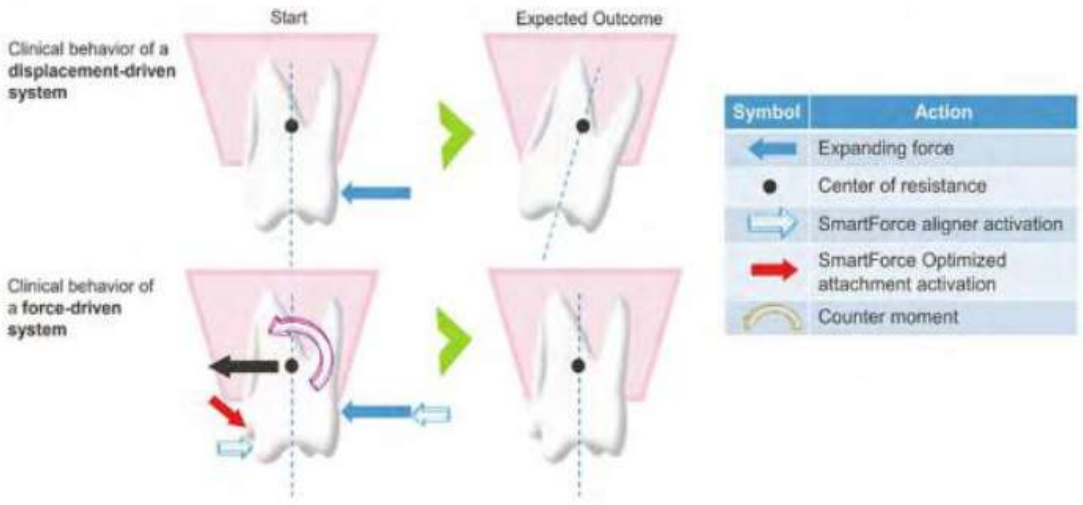

Figure1:- An illustration explaining clear aligner force systems highlights two types: the force-driven system and the displacement-driven system. The displacement-driven system focuses on physically shifting teeth to new locations, while the force-driven system applies controlled forces to achieve the desired tooth positions.[26]

Fabrication of clear aligners
Manual-
The process involves sectioning and sequentially repositioning individual teeth using a wax setup. After obtaining a working cast, the teeth are relocated into their planned positions. Aligner sheets are then molded onto the realigned models using pressure molding or a vacuum machine.[27]

Digital(CAD-CAM)[28]-
Impressions of patients are obtained digitally using an intraoral scanner and uploaded for virtual treatment planning.

Alternatively, traditional impressions using polyvinyl siloxane putty are casted, scanned, and uploaded.

Digital models of the teeth are then analyzed to determine if any Interproximal Reduction (IPR, a technique to create space between teeth) or expansion is necessary.

Teeth are digitally sectioned if needed for precise planning of tooth movements.

The Interproximal Reduction (IPR) prescription is reviewed digitally to ensure its validity and appropriateness. If accepted, the IPR is performed digitally.

Teeth are digitally moved into their correct alignment based on the treatment plan.

A digital overlay model is created by superimposing the final aligned model onto the original model.

Based on the digital overlay model, a sequence of clear aligners is fabricated.

Additional features such as force bumps, attachments (small shapes bonded to teeth for better aligner grip), or other auxiliaries may be planned digitally to aid in tooth movement as needed.

Wear Time For Cat

Wearing an aligner for 22 hours per day for 2 weeks (or as per the specific treatment plan) is essential to achieve the desired tooth movements effectively and efficiently in clear aligner orthodontic treatment.[12]Reducing the daily wear time of clear aligners can negatively impact the efficacy of incisor movements, such as labial inclination and buccolingual translation of mandibular incisors, rotation of maxillary central incisors, as well as buccolingual translation and intrusion of maxillary lateral incisors and overall treatment progress.[29]

Tooth Repositioning With Aligners

The use of clear polyurethane trays, often referred to as clear aligners, instead of traditional braces in orthodontic treatment has indeed sparked discussions regarding their efficacy in effectively realigning teeth. Clear aligners are capable of achieving various tooth movements with good precision, retrusion (moving teeth inward) is often considered the most precisely controlled movement, followed by rotation, fan-type expansion, and then protrusion.[30]Overall, clear aligners have proven effective in achieving satisfactory results in adjusting the bucco-lingual inclination of both maxillary and mandibular incisors, especially in cases of mild-to-moderate malocclusions.[31]

CAT isadvised in non-growing patients with mild-moderate malocclusions where extraction is not really needed.[32] In extraction cases in orthodontics, achieving proper root angulations requires the use of suitable attachments and a thorough understanding of the chosen orthodontic system.[33]Clear aligners can achieve highly predictable and controlled movements, such as moving molars backward by approximately 2.5 mm during maxillary molar distalization. They are also effective in closing gaps resulting from premolar extractions, with closures of up to 7 mm.[34]It is crucial to recognize that the thickness of aligners can present challenges, such as the potential loss of occlusal contacts. This factor has been noted to influence the final alignment of the occlusal plane in orthodontic treatment.[16]

Resorption Of Root With Clear Aligners Therapy

While fixed orthodontic appliances are associated with root resorption due to heavy forces, CAT may present a lower risk of root resorption overall because clear aligners use more gentle and controlled forces to gradually move teeth, with incisors being the teeth most commonly affected when it does occur.[34] Studies have found comparable incidence rates of root resorption between aligners and treatments involving light orthodontic forces.[36] Another study indicates that clear aligner therapy tends to result in lower severity and prevalence of root resorption compared to other orthodontic treatments.[37]

Patient console and desire with clear aligner treatment

Adult and teenage patients often prioritize aesthetic factors when selecting clear aligner therapy (CAT) as their preferred orthodontic treatment. Studies show that CAT's nearly imperceptible appearance, serving as a discreet alternative to traditional fixed braces, is a significant attraction for individuals.[38,39]Miller et al. conducted a study comparing the initial week of orthodontic treatment with fixed appliances and clear aligner therapy (CAT). They discovered several advantages associated with CAT. Patients undergoing CAT reported significantly less pain and discomfort during the initial stages, likely due to the absence of metal brackets and wires that could cause irritation.[40]Since the aligners can be removed for meals and drinks, CAT provides practical benefits, allowing for a

more consistent diet and dental care routine. Moreover, CAT can enhance the psychosocial well-being of adolescent patients by reducing social anxiety and boosting self-esteem.[41]

Top 6 companies driving the global clear aligner industry given in table 3 below.[42]

Company	Aligner brand	Software	Key features
Align Technology (San Jose, Calif)*	Invisalign	ClinCheck	• Global presence • Cloud-based treatment visualization • Global dental CAD/CAM software leader EXOCAD • Addresses simple and complex patients and posttreatment retention • SmartTrack material: yields constant subtle forces to improve tooth movement • SmartStage technology: programs sequential tooth movement to optimize treatment outcome predictability • SmartForce: customized attachments, biteramps, and power ridges
Institute Straumann AG (Basel, Switzerland)†	Clear Correct	Clear Pilot	• Clear Pilot: digital treatment planning • ClearQuartz Trilayer high performance aligns the material to ensure consistent accurate pressure • Smooth flat trimline that extends past teeth for greater retention: 2.5 × more retentive than scalloped aligners • Improved comfort • Stain resistant
Henry Schein (Melville, NY)‡	Reveal		• Web-based portal for simplified patient submission and treatment planning • ClearWear material • Precision fit, greater tooth contact reducing need for attachments • Accurate capture of interproximal contacts • Flexible and durable • Optimized trim for retention control • Uniquely clear and stain resistant
Dentsply Sirona (York, Penn)§	SureSmile	Open Software and Digital Lab	• Basis high-performance material and effective tooth movement • Open Software and Digital Lab to customize treatment planning • 50% fewer refinements • Customize the design of the trimline (scalloped or straight)
3M (3M ESPE, Maplewood, Minn)¶	Clarity Aligner Flex Clarity Aligner Force		• Web-based portal allowing access to treatment planning • Open platform allows use of any leading intraoral scanner • Clarity Aligner Flex: flexible 5-layer material indicated for a wire sequencing approach • Recommended for rotation and proclination • Clarity Aligner force: rigid material, indicated for a sequencial mechanics approach • Recommended for torque, expansion, torque, sequential intrusion, and bodily movement
ORMCO Corp (Envista, Brea, Calif)‖	Spark	Approver	• TruGEN and TruGEN Aligner material • Greater sustained force • Better contact surface retention • More control over predictable treatment planning • More efficient and effective tooth movement • Aligners are clearer, more comfortable, and stain resistant • Eruption guides, posterior bite turbos, bite ramps and anatomic bevel attachments

Conclusion:-

In conclusion, clear aligners represent a promising option in pediatric dentistry due to their numerous advantages. They provide effective orthodontic treatment while offering flexibility and convenience for young patients. The ability to remove aligners for eating and oral hygiene promotes better compliance with treatment regimens, potentially leading to improved outcomes. Moreover, clear aligners can enhance psychosocial well-being by reducing social anxiety and boosting self-esteem, particularly in adolescent patients. However, the success of clear aligners in pediatric dentistry hinges on thorough patient education and monitoring, as well as careful assessment of each patient's orthodontic needs. Continued research and development in this area are essential to further optimize treatment protocols and ensure long-term dental health benefits for pediatric patients undergoing orthodontic care with clear aligners.

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