

Are aligners effective and efficient in growing patients?



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Abstract

Background Proper development of deciduous and mixed dentition is essential to the oral health of growing patients, and early interceptive orthopedic or orthodontic treatments are indicated in specific clinical situations.

Nowadays, orthodontists are subjected to a lot of pressure from growing patients and their parents about the orthodontic appliances that should be used.

The aim of this article is to indicate how, when and why it is possible to effectively use aligners in growing patients.

Case reports Two case reports are illustrated, one with a CI.II subdivision, mono lateral cross-bite and vertical growth, and the other with a skeletal and dental CI.II, vertical skeletal pattern, proclined and fractured upper incisors.

The efficacy/efficiency ratio of aligners is analyzed in order to evaluate the suitability of this appliance for the treatment. Limits and advantages of aligners are widely discussed.

Conclusions Aligner treatment in growing patients shall be carefully studied to reach an optimal result. At present, a hybrid treatment strategy represents the best solution in growing patients with a complex clinical situation.

KEYWORDS aligner treatment, teenager patient, orthodontics

Introduction

Clear aligner treatment (CAT) is an orthodontic technique to align teeth by means of removable, comfortable and scarcely visible appliances. Clear aligners represent one of the most important orthodontic innovations over the past 10 years. They are routinely used in order to correct different kinds of malocclusions, such as deep bite, open bite, cross bite, crowding or Class II and III malocclusions [Giancotti et al., 2009; Giancotti et al., 2008; Giancotti et al., 2012; Fisher, 2010; Schupp et al., 2010; Bowman et al., 2015; Ravera et al., 2016].

However, clear aligners present some biomechanical limits that make this orthodontic technique strictly dependent on

orthodontic experience and knowledge. Indeed, the treatment often requires midcourse correction, refinements or braces to achieve optimal results [Bilello et al., 2022; Kravitz et al., 2009; Haouilli et al., 2020; Castroflorio et al., 2023; Zhang et al., 2022; Kravitz et al., 2022].

CAT was conceived for adult patients that, as a matter of fact, it represent 80% of the total treatments, while teen patients stand at approximately 20%. However, over the last years, there has been a strong interest of all aligner manufacturers to increase the number of treatments in growing patients, from ages 5-6, in early mixed dentition or even in deciduous dentition. To such purpose, firms claim that aligners have advantages over conventional appliances for interceptive treatment: fewer appointments, fewer emergency visits, reduced chair time and treatment duration.

However, questions concerning early aligner treatment include: are aligners indicated in growing patients? What is the correct timing? What are the actual clinical indications?

Scientific literature is clear about early interceptive treatment and the only reasons feature: bullying, psychological issues and proclined incisors to avoid dental trauma [Batista et al., 2018; Scheffel et al., 2014; Seehra et al., 2011].

There is no scientific evidence that dental alignment in deciduous or early mixed dentition (ages 5-7) can develop the dental arches and reduce crowding in permanent teeth [McInaney et al., 1980; Spillane et al., 1995; Little et al., 1990].

Regarding the clinical indications for early orthodontic treatment, these involve: anterior cross-bite, monolateral or bilateral dento-alveolar posterior cross-bite and severe incisor proclination.

The selection of the patient is strategic to obtain success with aligners, especially in case of dento-alveolar posterior cross bite. Indeed, one limit of aligners is maxillary arch expansion: it is possible to obtain only 73% of planned expansion because of typical molar and premolar buccal tipping generated by aligners [Jean-Philippe Houle et al., 2017; Tien et al., 2022; Quinzi et al., 2019; Lo Giudice et al., 2020].

On the other hand, the correction of proclined incisors is easy to obtain with aligners because it only needs tipping movement that is the most predictable dental movement in case of aligners.

The aim of this work is to show the usability aligners in grow-

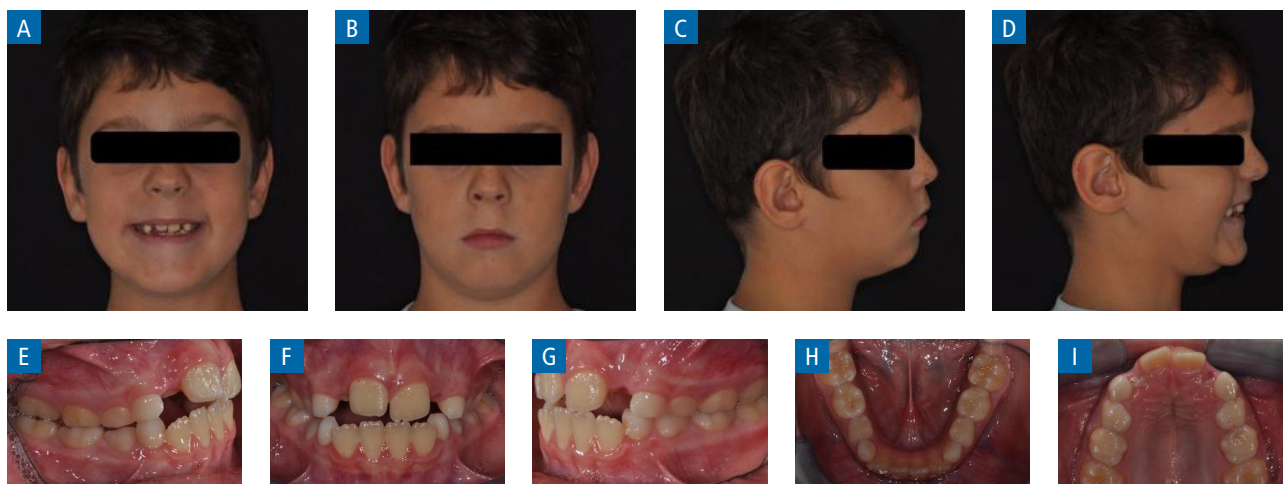


FIG. 1A-B-C-D-E-F-G-H-I Pre-treatment records



FIG. 2A-B Pre-treatment x-ray records

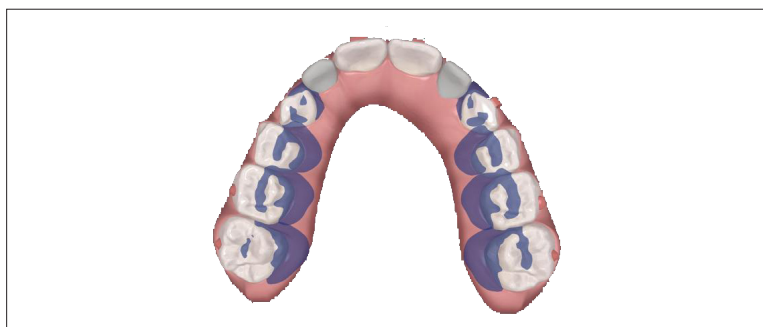


FIG. 3 Typical expansion of aligners

CEPHALOMETRIC ASSESSMENT	MEAN SD	PRE
SAGITTAL SKELETAL RELATIONS		
S-N-A	82°	80°
S-N-B	80°	76°
A-N-B	2°	4°
VERTICAL SKELETAL RELATIONS		
S-N/ANS-PNS	8°+/- 3°	4°
S-N/Go-Gn	32°+/- 3°	40°
ANS-PNS/Go-Gn	26°+/-1°	36°
DENTO-BASAL RELATIONS		
Maxillary Incisor Inclination 1/ANS-PNS	115°+/-4°	102°
Mandibular Incisor Inclination 1/Go-Gn	95°+/-5°	84°
DENTAL RELATIONS		
Overjet (mm)	2 +/- 2mm	2.5 mm
Overbite (mm)	2 +/- 2mm	-2.5 mm
Interincisal Angle 1/1	130°+/-5°	133°

TAB. 1 Cephalometric analysis

ing patients analysing the efficacy-efficiency ratio for adequately considering the possibility of employing clear aligners in specific clinical conditions.

CASE 1

A 7.6 year-old male presented in the mixed dentition phase (Fig. 1a-1i). Intraoral examination showed right dental Class II malocclusion, a monolateral right crossbite, mesial rotation of upper molars, absence of spaces for upper lateral incisors, anterior open bite and retroclined lower incisors.

The Cephalometric analysis (Table 1) confirmed a normal skeletal sagittal relationship, while a skeletal vertical growth pattern with SN/Go-Gn 40° and ANS-PNS/Go-Gn 36° was observed. (Fig. 2a-b)

The diagnosis was a right Class II subdivision with a monolateral dental cross-bite and a vertical growth pattern. Possible complications could arise from the patient medical history, that reported a

severe heart valve prolapse with consequent cardiologist's advice to avoid every risk of bacteremia and to favor an optimal oral hygiene during the orthodontic treatment. This medical condition drove our decision to select Invisalign® (Align Technology, San José, CA, USA) treatment.

Furthermore, monolateral crossbite and vertical growth pattern were two conditions that could be very well corrected by using aligners.

Treatment plan

The first approach included 2 steps of aligners, for a total of 55 aligners. The objectives were to expand the upper arch, to solve right dental cross-bite and to gain space for upper lateral incisors.

Vertical control was determined by what is known by "bite-block effect", typical of aligners, that allows a slight intrusion of molars with subsequent counter clockwise rotation of the mandible



FIG. 4A-B-C-D-E Control phase with aligners worn only at night time



FIG. 5A-B-C-D-E Late mixed dentition prior to the last 3 sets of aligners



FIG. 6A-B-C-D-E Final result with aligners, before braces-based treatment

[Rosa et al., 2019].

The ClinCheck Virtual Planning showed how aligners typically work to expand the upper arch in mixed dentition with initial upper molar distal derotation and after the expansion of deciduous to design an ideal archform (Fig. 3).

After using 55 aligners, the patient was invited to use the last pair of aligners only during the nighttime for about 8 months, in order to avoid molar extrusion and to control vertical skeletal growth (Fig. 4a-4e).

Therefore, in the last mixed dentition phase and while permanent teeth were extruding, 3 further sets of aligners were planned to continue maxillary arch expansion, to coordinate both arches, to level and to guide new erupting teeth (Fig. 5 a-5e).

Despite the presence of eruption compensators, the fit of aligners could represent an issue in growing patients during the last period of natural exfoliation of deciduous teeth and the eruption of the permanent canines and premolars.

At the fifth set of aligners, the patient was running out of compliance and, in agreement with both parents and cardiologist, it was decided to finalise the treatment by using braces (Fig. 6 a-b-c-d-e).

Treatment results

Please note that the treatment is still in progress, but recent clinical records show the final phases with braces on the upper arch, a proper bilateral Class I relationship, a good transversal coordination in both arches, suitable overbite and overjet (Fig. 7 a-7e).

At this point, it has become a simple orthodontic treatment based on leveling and alignment of both dental arches due to be completed over the next 4-5 months. The patient is controlled every 3 weeks by an oral hygienist to maintain an adequate plaque

control.

CAT has determined an optimal result: correction of posterior cross-bite, good sagittal relationship and vertical control. However, in terms of efficacy/efficiency ratio of the aligner, the outcome was not optimal. Indeed, the treatment featured more than 100 aligners, 42 months of treatment and, finally, braces adopted in the finishing phase. Overall, if compared to an alternative 2-phase treatment based on RME and braces for orthodontic finalisation, one can observe that the performed treatment described herein was not ideal in terms of efficiency.

An alternative treatment, with a first phase including RME and a second phase featuring braces, would have requested less patient compliance and a shorter treatment time. Furthermore, the alternative treatment would have definitely had lower management costs than the aligner-based treatment.

CASE 2

A 10-year-old female was evaluated to solve a severe issue: proclined and fractured upper incisors. Intraoral examination showed a bilateral dental Class II malocclusion, mesially rotated upper molars, proclined upper incisors and excessive overjet (Fig. 8 a-8i).

The Cephalometric analysis (Table 2) showed a skeletal Class II malocclusion with mandibular retrusion ($ANB = 5^\circ$, $SNB = 72^\circ$) and an increased gonial angle, denoting a backward mandibular rotation.

The diagnosis was a skeletal Class II relationship with a retrognathic mandible, an evident vertical growth pattern and a dental Class II division 1 malocclusion (Fig. 9 a-b).

Treatment plan

The treatment plan included Invisalign® Mandibular Advance-



FIG. 7A-B-C-D-E Finishing phase with braces.

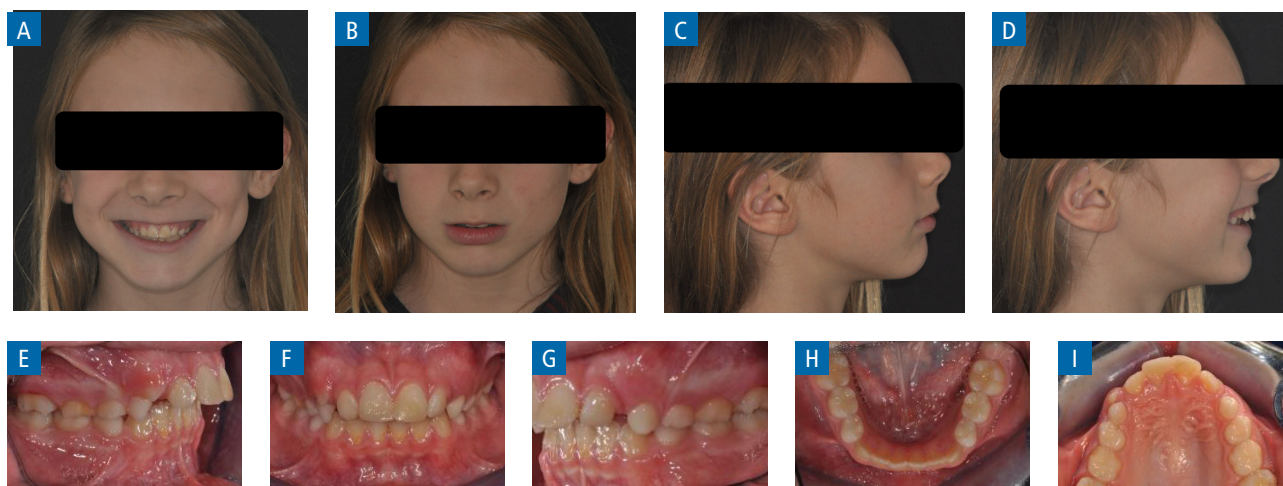


FIG. 8A-B-C-D-E-F-G-H-I Pre-treatment records

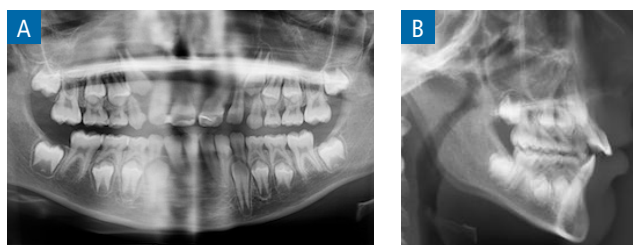


FIG. 9A-B Pre-treatment x-ray records

ment (MA) in three phases as follows:

1. MA Phase: this step was meant to align and to level teeth, to reduce upper incisor proclination, to expand and to coordinate both dental arches and to avoid molar extrusion for obtaining vertical control. At the same time, the wings of aligners, typical of Invisalign® Mandibular Advancement, worked to improve the skeletal Class II pattern, establishing skeletal and dental Class I relationships [Ravera et al., 2021].

The aligners were 26 and the patient was instructed to wear them 20 hours per day and to change aligners every two weeks. Conventional attachments were programmed in this phase. (Fig. 10 a-b-c)

2. Transitional Phase: this phase is strategic, especially in late mixed dentition when permanent teeth have not fully erupted yet, maintaining mandibular advancement during the growth peak. In this treatment phase, transitional aligners were 8, which the patient wore for 8 to 10 hours at night time only, and changed every month. During the transitional phase, in case of deciduous exfoliation with an improper aligner fit, a new scan for additional aligners is mandatory;

3. Additional Aligners: the last treatment phase started when

all permanent teeth were present in both arches. The aim was to finalise orthodontic treatment, to close spaces, to gain canine CI.I and to improve overbite and overjet. This step consisted of 62 aligners, which the patient wore for 20 hours per day with a weekly change.

Conventional attachments were planned to control upper canine distal tipping and upper molar buccal torque.

Treatment results

Following the MA phase of 13 months, Class II molar relationship was corrected and the transverse dimensions of both arches were coordinated (Fig. 11 a-11e).

At the end of the Transitional Phase, the molar Class I relationship was consolidated, but there were still spaces in the upper arch as well as a canine Class II relationship (Fig. 12 a-12e).

The last phase consisted of 62 aligners to guide canine distal tipping and to retrude upper incisors. Generally speaking, these are pure tipping movements with a high predictability when using aligners. At the end of the treatment, both skeletal and dental Class I relationships were obtained, and overjet and overbite were optimal. Alignment of teeth and smile were pleasant, but there was still an excessively gummy smile generated from vertical skeletal maxilla excess (Fig. 13 a-13f).

The Cephalometric analysis (Table 2) showed the improvement of the sagittal relationship, with an ANB reduced by 3° and an SNB increased by 3°. The vertical skeletal relationship was controlled while SN/GoGn remained almost unchanged (Fig. 14 a-b).

In this case, 7 aligner sets were employed, for a total amount of 96 aligners. Treatment duration was equal to 38 months. Patient's compliance was ideal. In terms of efficacy/efficiency ratio, it could be considered acceptable, especially when observing the outcomes deriving from the 8 months of the Transitional Phase,



FIG. 10A-B-C MA aligners with typical wings



FIG. 11A-B-C-D-E Intra-oral records at the end of the MA Phase



FIG. 12A-B-C-D-E Intra-oral records at the end of the transitional phase



FIG. 13A-B-C-D-E-F Final intra-oral records

CEPHALOMETRIC ASSESSMENT	MEAN SD	PRE	POST
SAGITTAL SKELETAL RELATIONS			
S-N-A	82°	77°	77°
S-N-B	80°	72°	75°
A-N-B	2°	5°	2°
VERTICAL SKELETAL RELATIONS			
S-N/ANS-PNS	8°+/- 3°	5°	4°
S-N/Go-Gn	32°+/- 3°	40°	41°
ANS-PNS/Go-Gn	26°+/-1°	35°	36°
MANDIBULAR GROWTH			
Co-Gn		98 mm	101 mm
DENTO-BASAL RELATIONS			
Maxillary Incisor Inclination 1/ANS-PNS	115°+/-4°	115°	113°
Mandibular Incisor Inclination 1/Go-Gn	95°+/-5°	90°	85°
DENTAL RELATIONS			
Overjet (mm)	2 +/- 2 mm	6 mm	4 mm
Overbite (mm)	2 +/- 2 mm	1 mm	4 mm
Interincisal Angle 1/1	130°+/-5°	120°	122°

TAB. 2 Pre and Post cephalometric analysis

when aligners were worn only night time with minimal stress burden for the patient.

Discussion

On one hand, aligners can offer advantages in an early interceptive treatment especially in specific conditions as bullying, poor oral hygiene with health risks and vertical growth control. On the other hand, timing is strategic in orthodontics and an early interceptive orthodontic treatment with aligners must be well programmed to obtain more benefits than side effects [Lynch et al., 2023].

In the real world, aligner treatments in growing patients may lead to long-lasting therapies, causing stress for patients and parents, lack of compliance and inadequate treatment results.

Scientific literature has evidenced that certain clinical conditions in growing patients, as dento-alveolar posterior bilateral cross-bite, can be better and more rapidly corrected by using a simple removable expansion plate [Van de Verde et al., 2021].

Early interceptive treatments with aligners present a limit in the plastic adaptability to deciduous exfoliation and extrusion of permanent teeth. This dynamic clinical situation requires further sets of aligners, with a consequent treatment time extension.

Another limit of aligners in growing patients is the difficulty to level the mandibular curve of Spee. This is a crucial step to achieve a flat occlusal plane to correct malocclusions [Goh et al., 2022; Quinzi et al., 2018].

The efficacy/efficiency ratio is strategic to appreciate the proper choice of the orthodontic appliance. It is important to educate

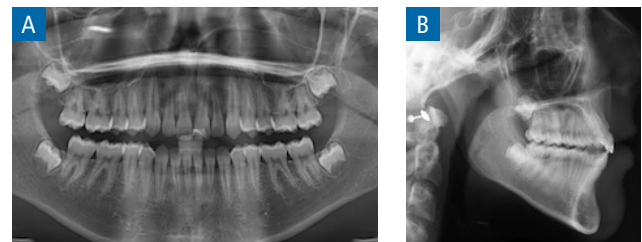


FIG. 14A-B Post-treatment x-ray records

new generations of orthodontists on the selection criteria of the best tool for every kind of malocclusion based on the efficacy/efficiency ratio rather than according to the wishes of the patient, parents or commercial interests of companies.

Last but not least, plastic toxicity is a new aspect to consider for establishing the proper cost/benefit balance of aligners.

For the first time last year, microplastics were detected in the human blood leading to potentially negative consequences for the general health, i.e. aggregations of macrophages, granulation tissue and foreign body response with inflammation and oxidative stress [Leslie et al., 2022].

A number of recent scientific studies have evidenced aligner-derived microplastics following orthodontic treatment. Although it is not possible to fully establish the consequences of microplastics in growing patients, researchers advise to use aligners with caution in young patients and only for a short period of time [Paul et al., 2020; Quinzi et al., 2023].

Conclusions

Aligners in growing patients can be used in specific clinical conditions and following a careful assessment of the efficacy/efficiency ratio.

As a matter of fact, if an orthodontist decides to use aligners without conducting a preliminary analysis, the risk is to waste time with additional aligner and midcourse correction. In certain clinical conditions, a hybrid treatment can be considered as a valid solution to overcome problems and save time.

The successful use of aligners in growing patients is not as simple and intuitive as one may think, and it requires an experienced orthodontist to plan the most suitable strategy.

In future, the possibility of producing aligners directly in office by means of 3D printers might help to raise the efficiency level of this orthodontic technique and to allow a more suitable use in growing patients.

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