"Efficiency of Invisalign® to promote mandibular advancement in growing patients: systematic review and clinical case."

Astrid Rodríguez López

Dissertação conducente ao Grau de Mestre em Medicina Dentária (Ciclo Integrado)

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CESPU
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Trabalho realizado sob a Orientação da Professora Doutora Teresa Pinho

Declaração de Integridade

Eu, acima identificado, declaro ter atuado com absoluta integridade na elaboração deste trabalho, confirmo que em todo o trabalho conducente à sua elaboração não recorri a qualquer forma de falsificação de resultados ou à prática de plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria do trabalho intelectual pertencente a outrem, na sua totalidade ou em partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores foram referenciadas ou redigidas com novas palavras, tendo neste caso colocado a citação da fonte bibliográfica.

Agradecimentos

À minha família, aos de sangue e aos que a vida pôs no meu caminho e que com o tempo, as vivências e o afecto se tornaram a minha casa. A todos aqueles que me acompanharam neste caminho, ajudando-me a remover as pedras que encontrei e que pouco a pouco me ensinaram a ultrapassá-las por mim própria, dando-me a confiança de que precisava e que muitas vezes sentia perdida.

Ao meu namorado, que veio como um presente e cuida de mim como um tesouro. Que me respeita, compreende e admira. Algo mútuo. Quem me ajuda a valorizar as sucessos e a abraçar as "aprendizagens".

À minha orientadora, Professora Doutora Teresa, que se tornou amiga por acaso da vida e eu acabei por admirar. Obrigada pelo vosso apoio durante a tese e pela vossa generosidade na transmissão e no ensino.

À minha terapeuta, com quem tenho trabalhado tanto para me aproximar à versão mais saudável e real de mim mesma.

Não tem sido um caminho fácil, mas com esforço, tenacidade e muito coração, os meus e eu conseguimos dar passos gigantescos em direcção àquilo que eu fantasiava quando era pequena; ser médica dentista.

Resumo

Introdução: A correcção da Classe II com retrognatia mandibular foi tratada com diferentes aparelhos funcionais que evoluíram ao longo do tempo permitindo um maior controlo e planeamento do avanço mandibular. Actualmente, temos a sistema Invisalign® que oferece o benefício de planear um avanço incremental personalizado, ao mesmo tempo que resolve o alinhamento. Isto, juntamente com a componente estética e removível, torna-a uma técnica muito atractiva para este tipo de tratamento.

Objetivo: Analisar a eficácia do avanço mandibular com o sistema Invisalign® obtendo os resultados da comparativa da revisão sistemática e estudo/resultados do caso clínico apresentado.

Materiais e Métodos: Foi realizado o estudo de um caso clínico no qual o avanço mandibular foi tratado com alinhadores com Precision Wings do sistema Invisalign®. Ao mesmo tempo, foi realizada uma pesquisa bibliográfica nas bases de dados PubMed, EBSCOhost, e Lilacs.

Resultados: O sistema Invisalign® apresenta resultados de efetividade no que respeita ao avanço da mandíbula no tratamento de pacientes em crecimiento, principalmente nos que se encuentram no estadio de maturação cervical CMV3; puberal.

Conclusão: O sistema Invisalign® pode ser considerado eficaz no tratamento do avanço mandibular**,** apresentando resultados semelhantes aos dos aparelhos removíveis convencionais. Contudo, não é tão eficiente quando comparado com os resultados obtidos com aparelhos fixos funcionais (Herbst ou Carriere). No entanto, são necessárias mais investigações.

Palavras-chave: Class II malocclusion, mandibular advancement, retrognatic mandibular, growing patients, Invisalign® and functional jaw orthopaedics.

Abstract

Introduction: Class II correction with mandibular retrognathia has been treated with different functional appliances that have evolved over time allowing for greater control and planning of mandibular advancement. Currently, we have the Invisalign® system that offers the benefit of planning a customized incremental advancement while resolving the alignment. This, along with the aesthetic and removable component, makes it a very attractive technique for this type of treatment.

Objective: To analyze the effectiveness of mandibular advancement with the Invisalign® system by comparing the results of a systematic review and a clinical case results.

Materials and Methods: The clinical case was performed in which mandibular advancement was treated by using Invisalign® System with Precision Wings. At the same time, a literature search was performed in PubMed, EBSCOhost, and Lilacs databases.

Results: Results: The Invisalign® system is effective in terms of mandibular advancement in the treatment of growing patients, mainly in those who are in a cervical maturing stage of CMV3; pubertal.

Conclusion: The Invisalign® system can be considered effective in the treatment of mandibular advancement, showing results similar to those of conventional removable appliances. However, it is not as efficient when compared to the results obtained by fixed appliances (Herbst or Carriere). However, further investigations are needed.

Keywords: Class II malocclusion, mandibular advancement, retrognatic mandibular, growing patients, Invisalign® and functional jaw orthopaedics.

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LIST OF ABREVIATIONS

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta - Analysis

PICOS - Patient, Intervention, Comparison, Outcome and Study design

Mm - Milimiters

Yo - Years old

MA - Mandibular Advancement

CVM2-3 - Stage of maturation of cervical vertebrae

PW - Precision Wings

TB - Twin-Block

EA - Essix plates + Class II elastics

LIST OF ANNEXES

Annexe 1- Informed Consent Form

1. INTRODUCTION

Class II malocclusion is one of the most common orthodontic problems, affecting one third of the population(1).

Amplifying the classic concept described by Angle, Class II malocclusions can have their origin in a sagittal problem, the cause residing in the basal bone, being called skeletal Class II, either because of the development and bone size of the maxilla and mandible or because of their position relationship. On the other hand, the dentoalveolar origin of these malocclusions is described, which may be due to an ectopic eruption of upper canines and the mesialization of premolars and molars(2).

In this revision we will focus on the basal origin; skeletal etiology. The most consistent diagnostic finding in Class II malocclusion is mandibular skeletal retrusion(3).

Class II malocclusions can be grouped into two divisions according to the inclination of the upper incisors. Class II division 1 is defined by an increased overjet due to the large proclination of the incisors and often also large protrusion. This type is characterized by transverse constriction of the maxillary and increased sagital length, associated with a deep and narrow palatal vault(4,5). Class II division 2, less frequently, is typified by retroinclined position of the incisors and a deep bite associated with the bone base. In contrast to the previous division, wide maxillary arches and a horizontal growth pattern are frequently(5,6).

The correction of skeletal Class II is not only intended to restore the proper sagital relationship of the dental arches but will also affect the soft tissues and facial projection of the patient's profile. A good diagnosis and early treatment planning are fundamental to provide a complete rehabilitation in terms of function, aesthetics and long-term stability(5).

A therapy able to enhance mandibular growth is indicated in Class II skeletal. Functional appliances aimed to stimulate mandibular growth by forward posturing of the mandible is available to correct this type of skeletal and occlusal disharmony in growing patients, the "population" on which this clinical case and systematic review is focused. The transition phase from the mixed dentition to the permanent usually coincides with an intense growth characterized by orthodontic and orthopedic changes(7). It is important to study and evaluate the optimal timing of the patient's treatment to maximize the efficacy thereof. For the determination of the patient's pubertal growth spurt there are several indicators such as height, dental development, presence of secondary sexual characteristics and hand-wrist radiographs. The stage of maturation of the cervical vertebrae, together with the other growth indicators, makes it possible to determine the pubertal growth peak, which is between stages 3 and 4(7,8).
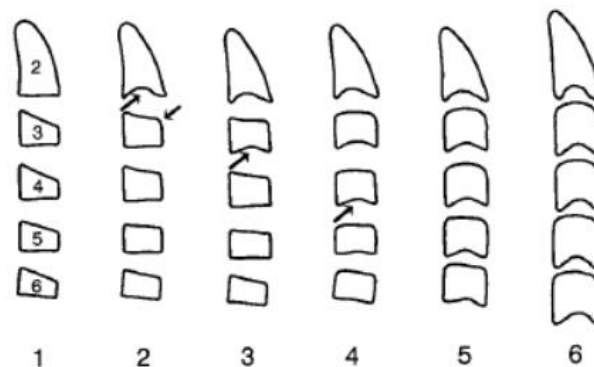
Figure 1. Cervical maturation stage

There are multiple appliances for the treatment of Class II skeletal with mandibular retrognathism, such as the fixed appliance of Carriere and Herbst, and the Twin-Block within the removable ones. All of them have in common the treatment approach, promoting the correction of mandibular retrusion and improving the cranio-cervical posture of this malocclusion(9,10).

The Mandibular Advancement device of the Invisalign® system, was launched in 2017 by AlignTechnology® as a removable treatment option for the skeletal Class II

approach in which mandibular advancement could be phased and customized, in addition to resolving dental alignment and leveling at the same time, without the need for two stages of treatment with two different devices, as was the case up to now.

It emerged as a new model of orthodontics that focused on the correction of malocclusion by means of clear aligners with lateral structures in the vestibular of posterior sectors of both arches called "Precision Wings". This device has undergone several modifications to ensure correct sliding and meshing of the lower PW forward of the uppers[1].

2. OBJECTIVE

The aim of the present systematic review and the clinical case presented was to measure the efficacy of treating Class II malocclusion in growing patients with the Mandibular Advancement Invisalign® system by evaluating the skeletal (mainly supplementary mandibular growth) and dentoalveolar effects.

3. MATERIALS AND METHODS

2.1 Selection criteria of the articles

The studies included in the systematic review were selected according to the below criteria (Table 1), following the PICOS strategy:

Table 1. PICOS strategy

P	Population	Individuals requiring mandibular advancement
I	Intervention	Invisalign® orthodontic treatment with mandibular advancement (MA)
C	Comparators	NA
O	Outcomes	Description of patient experience (and comparison with Twin-Block appliance)
S	Study design	Skeletal, dental and soft tissue effects

Inclusion Criteria

- Articles published from 2017 to August 2022 to focus our goal on identifying more recent evidence about mandibular advancement with Invisalign® system effectivess to be compared at the result of our clinical case;

- Clinical studies, case controls, effectiveness, identifying more recent evidence about conventional functionalremovable appliancesto be compared at the result of our clinical case;

- Studies written in English, Portuguese and Spanish languages;

- Articles whose study refers to patients in growing phase;

- Studies performed in humans;

- Prospective and retrospective clinical studies.

Exclusion criteria

- Abstract does not fit the topic;

- Studies in which the diagnosis, treatment and specific objective are not clearly described;

- Studies on treatments combined with other techniques (extractions, fixed appliances or surgery);

- Full reading did not provide revealing information;

- Systematic reviews, case reports, thesis and dissertations;

- Articles not available in the database referred in full text.

2.2 Data sources

Literature research was performed in the following databases: PubMed (via National Library of Medicine), EBSCOHost and Lilacs from 2017 to August 2022 using the following keywords and MeSH terms in the search strategy: "Mandibular advancement" AND "Invisalign OR Clear aligner". The search strategies are detailed in **Table 2**.

Table 2. Search strategy

				Results
PubMed	MeshTerms	Mandibular Advancement	"mandibular advancement" [MeSH Terms] OR ("mandibular"[All Fields] AND "advancement"[All Fields]) OR "mandibular advancement"[All Fields]	3,550
		Invisalign	"orthodontic appliances, removable"[MeSH Terms] OR ("orthodontic"[All Fields] AND "appliances"[All Fields] AND "removable"[All Fields]) OR "removable orthodontic appliances"[All Fields] OR "invisalign"[All Fields]	5,919
	Search		(Mandibular advancement) AND (Invisalign OR Clear aligner)	225
Lilacs	Search		Mandibular Advancement [Palavras] and Invisalign OR clear aligners [Palavras] and treatment OR correction OR therapeutics [Palavras]	3
EBSCOHost	Search		Mandibular Advancement [Palavras] and Invisalign OR clear aligners [Palavras] and treatment OR correction OR therapeutics [Palavras]	3

4. RESULTS

3.1 Selection of the articles

The literature According to the databases consulted and the search strategy, 231 articles were found. Duplicate articles were excluded, leaving only 226 articles. After reading the title and abstract, 122 articles were selected, of which 98 were excluded because they did not match the inclusion criteria or were not available. The remaining 4 articles were analyzed and included in this systematic review, which are shown in the flow chart **(Figure 2).**
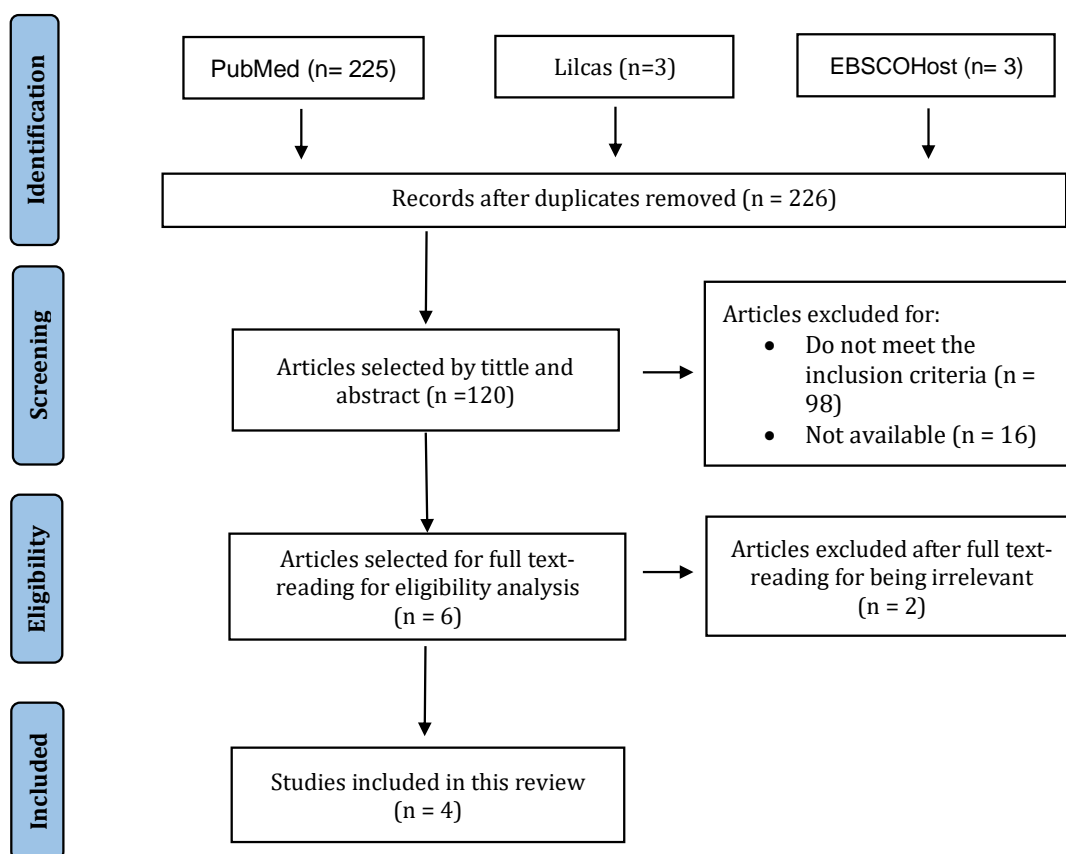

Figure 2: Flowchart of the study selection using PRISMA guidelines.

3.2 Data items and collection

The 4 articles selected from the literature databases were evaluated in full, and the data was extracted and organized.

Table 3. Structures the information obtained from the articles included in this systematic review and is organized as follows: authors' names and year of publication of the articles, title of the articles, number of participants and age range, etiology of the malocclusion, type of used appliance and the results obtained regarding the effectiveness of the treatments proposed.

Table 4. Structures the information obtained from the clinical case about the Invisalign® system.

Table 3. Data and outcomes from articles

Author and year of publication	Title	Sample (Range age and Nº of participants)	Etiology	Appliances/ Treatment	Outcomes
Ravera S. et al, 2021	« Short term dentoskeletal effects of mandibular advancement clear aligners in Class II growing patients. A prospective controlled study according to STROBE Guidelines »	Nº of participants: 72. 15 CVM2, 17 CVM3 and 32 control group Ranged age: 8 to 15 yo	Skeletal Class II with mandibular retrusion	Appliance: Invisalign® MA Treatment: - Mandibular advance planned 2mm/per 2 months. - Duration: 18 months in CVM2 group and 17 months in CVM3 group	- CVM2 group: mainly dentoalveolar effects - CVM3 group: dento-skeletal effects

Sabouni W. et al, 2022	« Invisalign treatment with mandibular advancement: A retrospective cohort cephalometric appraisal »	Nº of participants: 32. 13 females and 19 males Ranged age: Average 13 yo (9.9-14.8)	Skeletal Class II with mandibular retrusion	Appliance: Invisalign® MA Treatment: Multiples jumps	- Coefficient of efficiency of 0.16 mm per month, comparable to the mean efficiency of functional appliances. - Minor changes compared to the Herbst (0.28 mm/month) and Twin block (0.23 mm/month) - Average growth rate of the mandibular body length puberty phase: 1.96 mm/year - Minor skeletal changes - The lower incisor angulation was maintained
Caruso S. et al, 2021	« Mandibular advancement with clear aligners in the treatment of skeletal Class II. A retrospective controlled study »	Nº of participants: 20 CVM3 Ranged age: 9 to 11 yo	Skeletal Class II with mandibular retrusion	Appliance: Invisalign® MA and TB. Treatment: - 10 participants treated each appliance.	- Effectiveness of both. - Invisalign® MA seems to allow a better control of the upper frontal teeth position. - TB demonstrated a higher efficacy in increasing mandibular dimensions
Camci H. et al, 2021	« Comparison of skeletal and dentoalveolar effects of two different mandibular advancement methods: Conventional technique vs aesthetic approach »	Nº of participants: 24. 14 females and 10 males Ranged age – sustite for maturation phase: CVM3	Skeletal Class II division 1 with mandibular retrusion	Appliance: clear aligners with elastics and TB. Treatment: - 12 participants treated each appliance. - Auxiliaries: screws to correct maxillary transversal deficiency The mean number of screw activations was 31.2±2.0 in the TB group and 28.0±1.5 in the EA group.	- Effectiveness of both. - Similar results on movement the mandibular base to forward and on changes in soft tissue.

Legend of abbreviations: yo (years old), MA (Mandibular Advancement), CVM2-3 (stage of maturation of cervical vertebrae), mm (milimiters), TB (Twin-Block), EA (Essix plates

+ Class II elastics).

Table 4. Data and outcomes from clinical case

Author and year of publication	Title	Sample (Range age and Nº of participants)	Etiology	Appliances/ Treatment	Outcomes
Pinho T. 2020	« Efficiency of Invisalign ® to promote mandibular advancement in growing patients: Clinical case compared to systematic review »	1 female with 12 yo.	Skeletal Class II division 1 with mandibular retrusion	Appliance: Invisalign® MA and elastics. Treatment: - Phases: Pre-MA, MA, Additional Aligners. - Mandibular advance planned 2mm/per 2 months. - Auxiliaries: elastics Class II. - Duration: 15 months for Pre-MA and MA and 6 for AA.	- Effectiveness: significant advance and growth of the mandibular base.

Legend of abbreviations: yo (years old), MA (Mandibular Advancement), mm (milimiters), AA (Additional Aligner).

3.3 Results of the data

The study and analysis of the articles that integrate this systematic review has very similar values in their results. The etiology of the Class II malocclusion corrected and described in the articles used is of skeletal origin, so the initial aim of the studies was to determine the effectiveness of the correction of mandibular retrognathism by means of different systems, including clear aligner, mainly the Invisalign system, as stated in the title of this work.

Among the results, it is worth mentioning those obtained that allow us to affirm that the stage of maturity of the cervical vertebrae of the patient to be treated, anticipates the sagittal correction by a main effect of dentoalveolar development MCV2 and dentoskeletal for those grouped in a MCV3. This affirms that the pubertal stage has a greater potential for involvement and bone remodeling of the mandibular base than the pre-pubertal stage(3).

The following article describes results about the amount of advancement in mm that we achieved with Invisalign aligners in terms of mandibular advancement. The results obtained from the sample are similar to those achieved with conventional removable appliances such as Twin-Block, while remaining below those reported in the literature with respect to fixed appliances with Herbst(11). Supporting the similarity of the efficacy of TB and Invisalign Mandibular Avancement device in reference to forward movement of the mandibular base and soft tissue changes(4), with the particularity that the Invisalign approach allows greater control of lower incisor inclination(11) while TB allows greater mandibular dimension development(12).

3.4 Quality assessment

Table 5. Description of the aspects contained in the Newcastle-Ottawa quality assessment scale.

	Autor/Year		Ravera et al, 2021	Sabouni et al, 2022	Caruso et al, 2021	Camci et al, 2021
Selection	Representativeness of the sample	a) Truly representative of the average in the target population. ✶ (all subjects or random sampling) b) Somewhat representative of the average in the target population. (non-random sampling) c) Selected group of users. d) No description of the sampling strategy.	C	C	A✶	A✶
	Selection of the non exposed cohort	a) Drawn from the same community as the exposed cohort. * b) Drawn from a different source. c) No description of the derivation of the non-exposed cohort.	A✶	NA	A✶	NA
	Ascertainment of exposure	a) Secure record ✶ b) Structured interview c) Written self-report d) No description	A✶	A✶	A✶	A✶
	Demonstration that outcome of interest was not present at start of study	a) Yes✶ b) No	✶	✶	✶	✶
Comparability	Comparability of cohorts on the basis of the design or analysis	a) Study controls for treatment with mandibular advance. b) Study controls for any additional factor. *	✶	NA	✶	NA

Outcome	Assessment of outcome	a) Independent blind assessment ✶ b) Record linkage ✶ c) Self report d) No description e) Other	B✶	B✶	B✶	B✶
	Was follow-up long enough for outcomes to occur	a) Yes✶ b) No	B	B	B	B
	Adequacy of follow up of cohorts	a) Complete follow up - all subjects accounted for. ✶ b) Subjects lost to follow up unlikely to introduce bias - small number lost - > ____ %. ✶ c) Follow up rate < ____% d) No statement	D	D	D	D
Results			✶✶✶✶✶ Good quality	✶✶✶ Fair quality	✶✶✶✶✶✶ Good quality	✶✶✶✶ Fair quality

Table 6. Summary of the result of the methodological quality assessment of the included studies.

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE		
Study	**Number of stars**	**Conclusion**
Ravera et al, 2021	5	**Good quality**
Sabouni et al, 2022	3	**Poor quality**
Caruso et al, 2021	6	**Good quality**
Camci et al, 2021	4	**Poor quality**

5. CLINICAL CASE: MANDIBULAR ADVANCE WITH INVISALIGN ® SYSTEM

This clinical case study presented below was kindly provided by Full Professor Teresa Pinho, my thesis mentor.

4.1 Diagnosis and Ethiology

A 11 years old female patient presented for orthodontic consultation.

The extraoral clinical examination reveals facial symmetry, lip incompetence, atypical swallowing, support of the upper incisors on the lower lip in smile, upper dental midline centered with the facial midline, accentuated mandibular retrusion, convex facial profile, lower facial third lower than the proportion of the rest of the facial thirds, short lower face height.

On intraoral and radiographic examination, we observed a permanent dentition. The patient presents lower dental midline centered in relation to the upper, increased overbite, bilateral canine and molar total Class II 1, severe overjet of 12,9 mm (norm=2.5+2,5mm), a normal value of overbite with 4,4 mm (norm=2.5+2,5mm), increased curve of Spee and mesiorotted upper canines.

The cephalometric analysis reflects an anteroposterior skeletal Class II discrepancy with an ANB measurement of 6.9° (norm=3+2°) due to mandibular retrognathia (66,9 mm of length, norm (74,5 ± 5,0). Severe hypodivergent biotype. Is determined as mesofacial due to a FMA of value 25.7° (norm=25+3°) large proinclination of the upper incisor with 32.9° of UI/NA (norm=22+2°) and an over inclination of the lower incisor marked by an IMPA of 98.3° (norm=90+3°).

The etiology of this malocclusion is determined by hyperplasia of the anterior cranial base (79,9°, norm=74,5 ± 3,0°) and mandibular retrognathism/hyperplasia (62,8°, norm=74,5 ± 5,0°).

Figure 3. Extra-oral photographic recordings of the patient from profile, frontal and smile views pre-treatment.

Figure 4. Initial intra-oral photographic records of the patient from sagittal, frontal, overjet and occlusal views of both arches.
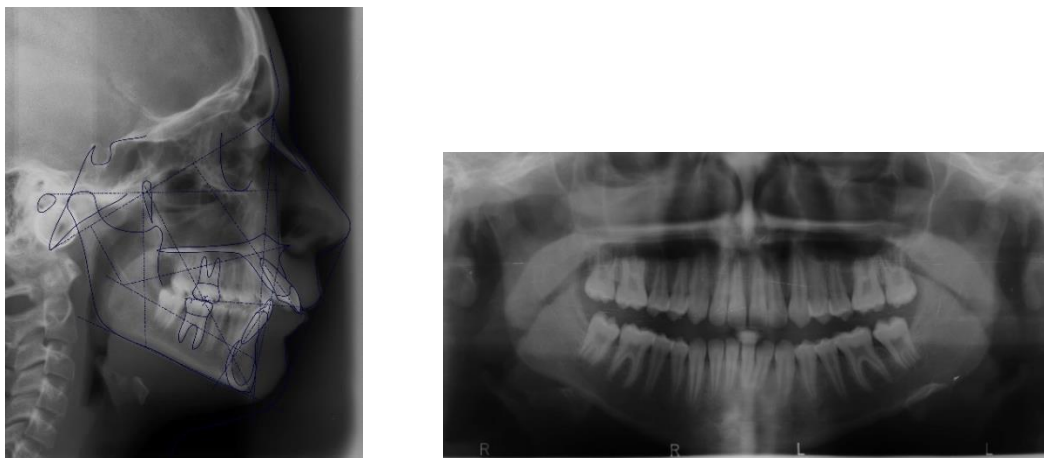

Figure 5. Teleradiographic and orthopantomography records of the patient pre-treatment.

4.2 Growth Evaluation

The patient was in an active growth phase. According to the cervical vertebral maturation stages of Baccetti et al. she was between cervical stage 2 (CS2) and 3 (CS3) and the peak of her growth was expected in one year from the time of initial evaluation.

4.3 Treatment Objectives

The treatment objectives are to correct the canine and molar relationship to Class I, intrusion of postero with correction of the curve of Spee, reduce the overjet and the overbite by correcting the inclination of the upper incisors planning their retraction together with the proinclination and intrusion of the lower incisors, correct rotation of 13 and 23, achieve optimal occlusion, maintain facial balance, and improve dental and facial esthetics.

4.4 Treatment Plan

Planning of a Pre-Ma phase, prior to mandibular advancement for the reduction of the deep bite, mainly. In addition, this phase is used to correct the inclination of the lower incisors, improve the curve of Spee by postero-inferior intrusion, improve the rotation of the upper canines and arch coordination. This phase is programmed with 24 aligners. After them, the Mandibular Advancement (MA) phase begins with a planning of 2 mm of jump distributed/programmed in three incremental jumps of 2 mm every 8 aligners ending with an edge-to-edge relationship, that is, with a slight hypercorrection of the advancement. After the last jump, one month of maintenance is planned for stabilization of the mandibular repositioning. Finally, 4 transitional aligners are planned to allow us to plan the second phase of treatment

while maintaining mandibular advancement for the patient with passive aligners featuring the Precision Wings.

The plan is to change the aligner every 7 days maintaining a compliance of 22 hours a day.

4.5 Treatment progress

The treatment progress of this patient was monitored monthly. At these clinic appointments, the fit of the last aligner delivered and the next one to be advanced were reviewed.

During the development of the Pre-MA phase, the use of Class II elastics from upper canine to lower molar with a cut to the aligner was determined. In this way we would not only have dentoalveolar potential, but it would also help with the torque correction of the upper and lower incisors. This is due because, in view of the fact that Invisalign is a closed system, if we trace from the aligner backwards, as in the case of the upper arch, we will be contributing to the loss of positive torque, one of the objectives set. On the other hand, in the lower arch, we intended to correct the inclination of the lower incisors, so fixing the elastic to the aligner on distal to the first molars, we would be applying forward traction and, therefore, positive to the torque increase.

Figure 6. Intra-oral photographs with the aligners of Pre-MA phase.

Once the Pre-MA phase was completed and the objectives achieved in terms of alignment, inclination and intrusion of the anterior sector were assessed, we continued with the next phase, that of mandibular advancement.

At this point, we dedicate a session to explain to the patient and parents how to slide the Precision Wings of the lower aligner in front of those of the upper aligner. We insist on the importance of this indication and the weekly aligner change prescription is maintained. In this case, due to the difficulty the patient had in positioning the lower arch correctly during the use of the aligners, an auxiliary technique was used to ensure the correct position and relationship of the Precision Wings. This is based on the placement of a Class II elastic from the upper canine (anchored to the aligner; hook) to the lower Precision Wing. The indication of this elastic is diurnal and nocturnal until the next check-up appointment.

Figure 7. Intra-oral photographs with the MA phase aligners and Class II elastics.

The mandibular advancement planned in this treatment plan, of 6 mm real* (edge-to-edge), was achieved in 8 months and stabilized during mes e meio. During this last period described, we proceeded with the planning of the second phase, for the completion of the case. For this, the patient was re-scanned and maintained the prescription of transitional aligners.

Figure 8. Intra-oral photographs at the end of the MA phase.

Regarding the planning of the Additional Aligners, the treatment objectives were to close the posterior open bite, level the curve of Spee, correct the lower midline and achieve the canine Class I on the left side. For this purpose, a vertical virtual jump was planned to close the posterior open bite once the curve of Spee was corrected by intrusion of the posteroinferior sector. As another of the objectives was the correction of the midline and the canine Class, a rotational and sagital component was introduced to the jump. The latter is something that is inherent to a vertical correction of reduction of the vertical dimension, since when performing this movement and, taking into account that the ATM joint has a hinge axis, the mandible suffers an anterorrotation, which is perfect for this planning. For this purpose, a left Class II short elastic was prescribed for day and night use. This described phase was planned with 13 aligners.

Figure 9. Intra-oral photographs with Additional Aligners and Class II left.
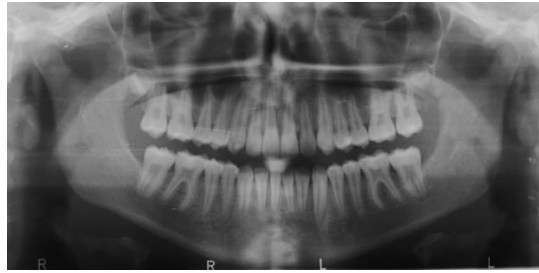
Figure 10. Orthopantomography records during Additional Aligner phase.

At this point, after 1 year and 9 months of treatment, a next phase, the occlusal settling phase, is planned. In this phase, the patient is instructed to wear the aligners only at night. After 3 months, we took a record using iTero technology that allows us to make a comparison of the occlusal forces and contacts with respect to the last scan performed after the completion of the previous phase, that of the Additional Aligners.
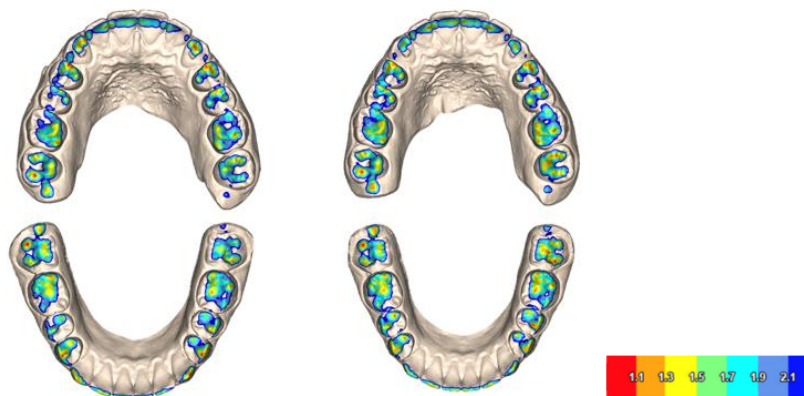

Figure 10. Occlusal contacts before and after the occlusal settling phase. iTero "Occlusogram" tool.

4.6 Treatment Results

At the end of the treatment, there was a significant advance and growth of the mandibular base reaching 66.9 mm, which is denoted in a clear improvement of the facial profile and aesthetics of the patient with an increase in the projection of the

chin approaching a straight profile. The proportionality of the lower middle third has been recovered and the labiomental and nasolabial angles were improved.

Lip competence has been achieved and the smile line becomes correct, showing 2/3 of the clinical crown of the upper incisors.

The overjet was reduced to 4.1 mm while the overbite remained stable at the end of the treatment with a value of 4.2 mm. The canine's rotations were corrected and the curve of Spee leveled. In addition, a bilateral Class I canine and molar was achieved.

The current biotype of the patient is described as normodivergent. As for the FMA value, it has remained within the norm and without much variation, 23.5°, so we are still at a value that fits in mesofacial. Both the IMPA and the interincisive angle have been reduced, but without reaching normal values. As for the ANB, it was reduced to 5°, which confirms the improvement in the sagital relations between the upper and lower bases, reaching a skeletal Class I with the orthodontic treatment.

Figure 12. Extra-oral photographic recordings of the patient from profile and smile views post-treatment.

Figure 13. Final intra-oral photographic records of the patient from sagittal, frontal, protrusion and occlusal views of both arches.
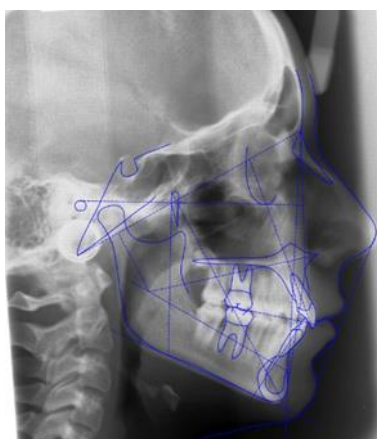

Figure 14. Final teleradiography with cephalometric tracings.

Table 7. Measurement of pre- and post-treatment cephalometric values.

Measure	Unit	Pretreatment values (T0)	Post-treatment values (T1)
FMA (MP-FH)	degrees	25,7	23,5
IMPA	degrees	98,3	99,3
SNA	degrees	78,7	78,9
SNB	degrees	71,8	73,9
UI ao N-A	degrees	32,9	18,9
ANB	degrees	6,9	5
Anterior cranial base length	mm	77,9	80,6
Mandibular length	mm	62,8	66,9
Interincisal angle	degrees	110,9	125,6
Overjet	mm	12,9	4,1
Overbite	mm	4,4	4,2

Angular cephalometric points measured: FMA (MP-FH), angle between Frankfort horizontal plane and mandibular plane; IMPA, angle between lower incisor long axis and mandibular plane; SNA, sella–nasion–point A angle; SNB, sella–nasion–point B angle; UI ao N-A, upper incisor–nasion/point A line angle (in this case); ANB, point A–nasion–point B angle.

6. DISCUSSION

The clinical case presented compared to the systematic review aims to discuss the efficacy of mandibular advancement treatments in skeletal Class II patients with mandibular retrognathism performed with the Invisalign® System for mandibular advancement with the Precision Wings.

In several articles included in this systematic review, they focused their study objective on a comparison of the effectiveness and predictability of mandibular advancement with conventional removable appliances, Twin-Block in comparison with the clear aligners and Precision Wings of the Invisalign® system(13). This type of approach helps us to measure and track the feasibility of treating this malocclusion with other strategies since there are not many studies on this subject to date. As we discussed earlier, Invisalign mandibular advancement is a relatively recent system as the first launch of the brand of aligners with Precision Wings was in 2017.

In the present systematic review, the mandibular advancement values achieved with TB and MA are closely matched. The standard of advancement achieved per month captured in the data represented 0.23mm per month in case of a case treated with TB and 0.16 mm in case of MA. However, growth rate of the mandibular body length puberty phase: 1.96 mm/year(11). This could be related to the adaptability and gradual progress of developmental age cases treated with MA due to the possibility of planning gradual incremental jumps. In spite of these results, certain studies and authors maintain the superiority of convention appliances such as Herbst or Carriere within the fixed technique in achieving better results(10,11). After all, this is a technique that has been used for a long time, so there are many cases studied and there is great traceability of the results and predictability.

The viability of mandibular advancement does not lie solely in the technique or system chosen by the orthodontist, nor in the patient's compliance, but a crucial part of the success of orthodontic treatment is based on studying and determining the ideal time to start the approach. By this we mean the stage of development of the patient. It is true that nowadays interceptive treatment is promoted, since it mostly alleviates severe malocclusion conditions in the future, but in this case we should focus on the etiology of Class II to foresee the best result and determine the moment to start orthodontic treatment(12,14)

As has been reported in several articles in this review, mandibular advancement treatment, either with TB or MA, at the cervical vertebral skeletal skeletal maturational development stage named as CVM2 according to Baccetti's Classification, in a correction mainly of dentoalveolar effect. At this stage, the correction effect of the basal mandibular relationship tends to be minimal(7,8,15–17). Therefore, it can be determined that this maturational phase may be ideal for addressing Class II dentition etiology.

That said, there are situations in which waiting until the prepubertal phase might be ruled out by the orthodontist. Part of these reasons may lie in the need to rehabilitate the patient's masticatory function in situations where occlusal stability due to the maxillary relationship present does not allow for normal swallowing(5,6,12,18,19). This scenario also includes the need to avoid dental trauma due to a large proinclination and exposure of the upper incisors, or even the need to avoid further injury to the patient in cases of severe deep bite in conjunction with a large overjet that causes the incisor sector of the patient's lower arch to impact with the palatal mucosa behind the upper incisors(16,17). Speech impairment and possible bullying are also other reasons why the orthodontist, despite the patient being in a CVM2 and having a Class II skeletal etiology, might plan a mandibular advancement approach(3).

According to the results obtained in the studies of the articles and in the clinical case presented, patients treated in the CVM3 phase show a clear skeletal effect in

the correction of Class II with a development of the mandibular base and an advancement of the mandibular base in relation to the anterior cranial base(20–22).

Nevertheless, the factors to be taken into account are not identified or specified, so the phase identified with the pubertal growth period is the one in which a more realistic approach to the maturational phase of the patient is advocated and, therefore, the orthodontist will be more accurate when planning the orthodontic approaches to his(20).

As well as mandibular advancement, other movements are achieved in the planning of this type of correction. In general, both with conventional removable appliances, TB, and with the Invisalign system, retrusion of the upper incisors and an increase in the SNB angle at the same time as a reduction of the ANB(4,23). Due to the different design and arrangement, the TB, because of the labial bow, enhances more the decrease of the ANB angle by the final possition of upper incisors. On the other hand, the Invisalign system controls/maintains the inclination of the lower incisors more reliably(11,12,24).

As an advantage to MA, the Invisalign system allows the possibility to work on alignment and concrete movements during mandibular advancement. This with some particularity, since the planned movements in the pieces on which the Precision Wings are supported, not being able to carry optimized attachment or activations and hardly much control of the aligner, are complex to achieve. Therefore, in the ClinCheck® file, before situations such as those described, there are 2 virtual phases in which we would see the patient's occlusion without the aligners and what the patient's alignment and occlusion would be like once the next phase, Additional Aligners, has been.

One effect that can occur in the treatment of skeletal Class II is a remodeling at the anterior cranial (maxillary) bone level with retrusion of its projection(8,13). In the literature analyzed in this review, both TB and MA have minimal power to affect it(11).

7. LIMITATIONS

- The articles were selected in the time range from 2012 to 2022 to focus our goal on identifying more recent evidence on the effectiveness of mandibular advancement treatments.

- There were a limited number of articles on the desired content due to Invisalign® is a new approach to mandibular advancement treatment, introduced in 2017, we needed recent information about conventional mandibular advancement appliances to be compared at.

- However, further investigations are needed regarding the Mandibular Advancement with Invisalign® system in order to be able to perform predictability studies with a larger sample of cases and, therefore, greater traceability.

8. CONCLUSION

The outcome of our clinical case compares to the systematic review about conventional mandibular advancement appliances, led to the conclusion that:

- The data analyzed suggest that the Mandibular Advancement with Invisalign® system has similar outcomes when compared to conventional removable appliances regarding the efficiency of mandibular advancement (literature data), although the efficiency of conventional fixed appliances may be difficult to replicate;

- There is no significative difference between TB or MA amount of mandibular advancement. They can be considered two effective therapeutical approaches to mandibular advancement in growing patients;

- The Invisalign® system can provide an excellent aesthetic during treatment, ease of use, comfort of wear and superior oral hygiene than fixed appliances;

- Pre-pubertal stage of growth, Invisalign® aligners or Twin-Block appliance, with Mandibular Advancement feature, have mainly dentoalveolar effects in the short-term period. When used in the pubertal growth phase, the short-term effects of Mandibular Advancement feature are dento-skeletal

The Invisalign® system is at the technological forefront of removable orthodontic treatment. The fact that it is removable plays an important role in patient compliance with treatment. However, further research using the Invisalign® system to produce mandibular advancement is needed to better understand the dentoalveolar and, primarily, the equeletal response in child and adolescent treatment. Therefore, more studies on this topic are essential, which would

contribute to a more accurate and informed answer to the structural question of this clinical case results compared to a systematic review.

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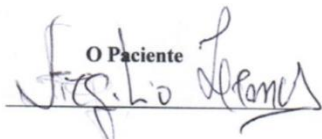
10. ANNEXES

Annexe 1. Informed Consent Form

Consentimento Informado

"Concedo todos os direitos para publicar fotografias ou outras imagens deste paciente no manuscrito.

Atesto que a paciente, neste caso o seu tutor por ser menor de idade, possui consentimento informado no consultório que atestam a publicação das suas imagens em artigos".

30 de setembro de 2022

O Paciente

(O tutor, pai)

O Médico