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Effects of Interceptive Orthodontic Treatment on Skeletal, Dental, and Soft Tissue Changes in Paediatric Patients with Class II and Class III Malocclusions

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Abstract

Background

Untreated malocclusions can negatively affect oral function, facial aesthetics, and psychological well-being. Interceptive orthodontics plays a crucial role in promoting balanced and functional facial growth. In recent years, clear aligners have been proposed as an aesthetic and effective alternative to traditional functional appliances.

Aim

To evaluate the skeletal, dental, and soft tissue effects produced by functional orthopaedic appliances in Paediatric patients with Class II and Class III malocclusions.

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Materials and methods

A retrospective study was conducted involving 69 patients (39 with Class II and 30 with Class III malocclusions; mean age 10.4 ± 1.7 years). Lateral cephalograms taken before and after treatment were analyzed using cephalometric parameters (SNA, SNB, ANB, Wits, Co–A, Co–Gn, dental inclinations, and soft tissue variables). Statistical tests were applied to assess correlations between skeletal, dental, and aesthetic changes.

Results

In Class II patients, significant mandibular advancement was observed (SNB +1.81°; $p < 0.001$), accompanied by a reduction in sagittal discrepancy (ANB −1.15°) and improvement of overjet (−3.9 mm). In Class III patients, treatment stimulated maxillary growth (SNA +3.33°; $p < 0.001$) and corrected anterior crossbite (overjet +1.96 mm). Both groups exhibited facial profile improvement, particularly in upper lip position, achieving better facial harmony.

Conclusions

Interceptive orthodontics represents a key component in Paediatric dentistry for the early management of malocclusions. Its use during the mixed dentition phase promotes balanced skeletal development, improves occlusal function and facial aesthetics, and reduces the need for complex orthodontic or surgical treatments in adulthood.

Keywords

Malocclusion; Class II; Class III; interceptive orthodontics; Clear aligners.

Introduction

According to the World Health Organization (WHO), malocclusions are the third most prevalent oral condition in the paediatric population, surpassed only by dental caries and periodontal disease [1]. They are defined as an alteration in the relationship between skeletal bases and dental arches during occlusion, which can affect masticatory function, facial structure, and psychological well-being [2,3].

The mixed dentition stage represents a critical period for the management of malocclusions. During this phase, dental and skeletal structures are undergoing continuous growth, presenting both opportunities and challenges for early intervention. This transitional period lays the foundation for the child's future occlusion and overall oral health. Consequently, orthodontic treatment initiated during mixed dentition — known as interceptive orthodontics — aims to address early skeletal and dental irregularities to prevent or minimize more complex orthodontic problems later in life [4,5].

Functional orthopaedic appliances help modify muscular function, optimize maxillofacial growth, and guide erupting teeth towards more favorable positions [5].

In Class II malocclusion, characterized by a distal relationship of the mandibular arch relative to the maxilla, functional appliances seek to stimulate mandibular growth and improve sagittal relationships. Its aetiology may be dental, skeletal, or a combination of both, representing approximately 25–30% of malocclusions in children. The most frequently used functional appliances include the Twin-Block, Herbst, Bionator, Frankel appliance, and Bimler [6-10].

Conversely, Class III malocclusion is defined by a mesial relationship of the mandibular arch relative to the maxilla and is less prevalent than Class II. Traditionally, treatment has involved rapid maxillary expansion to induce a controlled opening of the circummaxillary and palatal sutures, followed by maxillary protraction. In recent years, the introduction of indirect skeletal anchorage systems has improved the predictability of such treatments [4,11,12].

More recently, functional clear aligners have emerged as an aesthetic and comfortable option for the management of both Class II and Class III cases. However, their evidence in paediatric populations remains limited due to the scarcity of clinical studies [13,14].

The present study aims to comprehensively analyse the skeletal, dental, and soft tissue changes induced by different types of interceptive orthodontic appliances in children with Class II and Class III malocclusions, thereby contributing updated clinical evidence on their effectiveness.

Materials and Methods

A retrospective, observational, and analytical study was conducted on patients treated with interceptive orthodontic appliances during the mixed dentition phase. All procedures complied with the ethical principles of the Declaration of Helsinki and were approved by the Ethics Committee of Universidad CEU San Pablo (Madrid, Spain).

Initially, participants aged between 6 and 12 years — corresponding to the mixed dentition stage — were selected regardless of sex. All patients had been diagnosed with Class II or Class III malocclusion requiring interceptive treatment.

Inclusion and Exclusion Criteria

Inclusion criteria for class II patients

- Skeletal Class II malocclusion, Division 1 or 2 (ANB ≥ 4°).
- Mandibular retrognathism (SNA ≥ 82°, SNB ≤ 78°).
- Overjet ≥ 5 mm.
- Bilateral Class II molar and canine relationship.
- Cervical vertebral maturation stages 2–3 (CVM2–CVM3).
- Convex facial profile on pre-treatment photographs.

Inclusion criteria for class III patients

- Skeletal Class III malocclusion (ANB ≤ 1°), with anterior crossbite or edge-to-edge incisal relationship.
- Class III molar relationship (Angle’s classification) in mixed dentition or mesial step in primary dentition.
- Straight or concave facial profile.
- Cervical vertebral maturation stages 2–3 (CVM2–CVM3).

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Exclusion criteria

- Previous orthodontic treatment.
- Age > 12 years or presence of permanent dentition.
- History of cleft lip and/or palate.
- Syndromic or craniofacial anomalies.
- Incomplete clinical records or loss to follow-up.

Sample Size Calculation

For this retrospective study, clinical records from a private dental practice (Guadalajara, Spain) were reviewed. Over a three-month period, approximately 70 paediatric patients were treated. To determine the optimal sample size, the standard formula for finite populations was applied, assuming a 90% confidence level and a 5% margin of error. Under these parameters, a minimum of 40 patients was required.

After applying the inclusion and exclusion criteria, 69 participants were selected (mean age: 10.4 ± 1.7 years), of whom 39 presented Class II malocclusion (22 boys, 17 girls) and 30 presented Class III malocclusion (14 boys, 16 girls).

Orthodontic Appliances

For Class II malocclusions, the following appliances were used: Twin-Block, Bionator, Herbst, Pendulum (Hilgers), Klammt, and mandibular advancement clear aligners.

For Class III malocclusions, treatment consisted of facemask therapy combined with rapid maxillary expansion (Hyrax or McNamara) or facemask with clear aligners.

Data Collection and Cephalometric Analysis

Data collection took place between 2022 and 2024. After obtaining written informed consent from the patients' legal guardians, demographic and clinical data were recorded. Lateral cephalometric radiographs were obtained at two time points:

- T1: baseline (before treatment)
- T2: after completion of functional therapy
- Each participant was assigned a random numerical code to maintain anonymity.
- Measurements were performed using NemoCeph software by a single calibrated examiner, with a Kappa index of 0.812, indicating high intra-examiner reliability.

The following variables were analyzed:

- Skeletal: SNA, SNB, ANB, Wits appraisal, Co–A, Co–Gn, SN–GoGn.
- Dental: inclination and protrusion of upper and lower incisors, overjet, overbite.
- Facial (soft tissue): nasolabial angle, upper lip position (UL), and lower lip position (LL).

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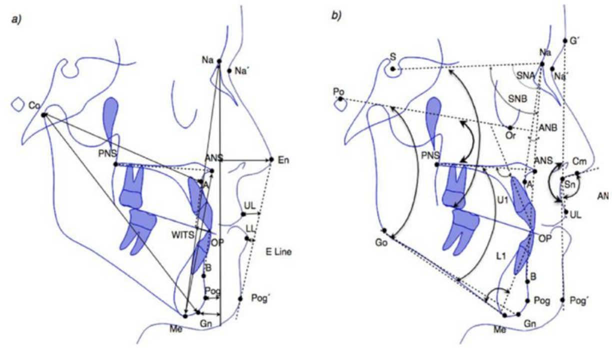

Figure 1: Graphic representation of cephalometric landmarks and linear and angular measurements [15].

Statistical Analysis

Normality of the data was tested using the Shapiro–Wilk test, and paired Student's t-tests were applied to compare pre- and post-treatment values (T1 vs T2). The level of statistical significance was set at $p < 0.05$. All analyses were performed using IBM SPSS Statistics v22.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 69 patients were included in the study: 39 with Class II and 30 with Class III malocclusions. Patients with Class II malocclusion were treated using Twin-Block, Bionator, Herbst, Pendulum (Hilgers), Klammt, or mandibular advancement clear aligners, whereas those with Class III malocclusion received facemask therapy combined with rapid maxillary expansion (Hyrax or McNamara) or facemask with clear aligners (Table 1).

Type of Class II Appliance	Sample size (n = 39)	Type of Class III Appliance	Sample size (n = 30)
Twin-Block	19	Acrylic expander + FM	13
Mandibular advancement aligners	8	Hyrax expander + FM	11
Bionator	6	Aligners + FM	6
Pendulum (Hilgers)	3	—	—
Klammt	3	—	—

Table 1: Distribution of orthopaedic appliances used in patients with Class II and Class III malocclusions. (FM = facemask)

Class II Malocclusion

Skeletal evaluation

Post-treatment analysis showed positive skeletal changes. The SNA angle increased slightly (+0.96°), reflecting mild forward maxillary growth, whereas the SNB angle increased significantly (+1.81°), indicating a clear mandibular advancement. The reduction in ANB (−1.5°) and Wits (−0.66 mm) values suggested a substantial improvement in sagittal skeletal relationships between the maxilla and the mandible — characteristic of successful orthopaedic correction.

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Dental evaluation

Interceptive treatment led to clear dental improvements. The mean overjet decreased by 3.9 mm, confirming a significant correction of upper incisor protrusion. The overbite was reduced by 2.20 mm, improving the vertical occlusal relationship. Initially, upper incisors were proclined and protruded; after treatment, they showed slight retraction and up righting (−0.24°; −0.92 mm), although not statistically significant. Lower incisors, initially retroclined and retruded, exhibited marked improvement in inclination (+2.26°) and position (+1.12 mm), thereby normalizing the overjet.

Facial (soft-tissue) evaluation

Soft-tissue profiles also improved. The convex facial profile typical of Class II malocclusion became more balanced after treatment: the upper lip retracted significantly (−0.96 mm), enhancing facial harmony. The lower lip showed a slight but non-significant retraction.

Variable	Mean difference (POST − PRE)	t	p-value
SNA	+0.96°	3.439	0.0014
SNB	+1.81°	5.9781	< 0.0001
ANB	−1.15°	−6.0982	< 0.0001
Wits	−0.66 mm	−2.9749	0.0051
Co–A	+2.20 mm	2.5993	0.0132
Co–Gn	+6.02 mm	5.2915	0.000005
SN–GoGn	+1.51°	2.2869	0.0285
U1 Inclination	−0.24°	−0.1742	0.8626
U1 Position	−0.92 mm	−1.8823	0.0674
L1 Inclination	+2.26°	2.1164	0.0409
L1 Position	+1.12 mm	3.0615	0.004
Overbite	−2.20 mm	−6.4187	< 0.000001
Overjet	−3.59 mm	−8.0444	< 0.000001
Nasolabial angle	+2.60°	0.8288	0.4123
Upper lip position (UL)	−0.96 mm	−3.1297	0.0034
Lower lip position (LL)	−0.18 mm	−0.4691	0.6416

Table 2: Cephalometric changes before and after treatment in patients with Class II malocclusion (paired t-test) (Units: angles in degrees, distances in millimeters; SD = standard deviation; ns = not significant)

Class III Malocclusion

Skeletal evaluation

Significant skeletal changes were observed in both the maxilla and mandible. Interceptive treatment stimulated maxillary growth, reflected in an increase in SNA (+3.33°) and in the Co–A length (+4.89 mm). Simultaneously, SNB increased moderately (+1.69°), indicating controlled mandibular advancement.

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Consequently, ANB and Wits values improved, confirming effective sagittal correction and enhanced intermaxillary relationship.

Dental Evaluation

Patients initially presented a negative overjet, typical of anterior crossbite. Following treatment, this parameter changed significantly, with a mean value of +1.96 mm, confirming successful correction. Overbite showed no significant variation (+0.26 mm) but a clinically improved vertical relationship. Upper incisors, initially retroclined and retruded, exhibited mild proclination (+2.76°) and protrusion (+0.41 mm), while lower incisors showed proclination (+1.64°) and protrusion (+0.87 mm) — all contributing to a normalized overjet.

Facial (soft-tissue) evaluation

The facial profile, usually concave in Class III patients, improved following treatment, although differences were not statistically significant. A slight reduction in the nasolabial angle (−2.66°) and minimal retraction of the upper (−0.14 mm) and lower lips (−0.75 mm) were observed, reflecting a tendency towards a straighter and more balanced profile.

Variable	Mean difference (POST – PRE)	t	p-value
SNA	+3.33°	5.4628	0.000007
SNB	+1.62°	3.4154	0.0019
ANB	+1.69°	4.9199	0.00003
Wits	+3.92 mm	7.9448	< 0.000001
Co–A	+4.89 mm	5.6438	0.000004
Co–Gn	+6.15 mm	5.0812	0.00002
SN–GoGn	+2.17°	2.2328	0.0334
U1 Inclination	+2.76°	1.9706	0.0583
U1 Position	+0.41 mm	0.7340	0.4687
L1 Inclination	+1.64°	1.3965	0.1731
L1 Position	+0.87 mm	2.0620	0.0482
Overbite	+0.26 mm	0.6539	0.5183
Overjet	+1.96 mm	3.3683	0.0022
Nasolabial angle	−2.66°	−1.9577	0.0599
Upper lip position (UL)	−0.14 mm	−0.4443	0.6601
Lower lip position (LL)	−0.75 mm	−1.9049	0.0667

Table 3: Cephalometric changes before and after treatment in patients with Class III malocclusion (paired t-test) (Units: angles in degrees, distances in millimeters; SD = standard deviation; ns = not significant).

Discussion

This retrospective study aimed to analyse the effects of interceptive orthopaedic treatment using different functional appliances in growing patients with Class II and Class III malocclusions. Skeletal, dentoalveolar, and soft tissue changes were assessed, taking into account the influence of malocclusion type and patient sex on therapeutic response.

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Interceptive orthopaedic treatment during the growth phase represents a valuable clinical approach, as it enables clinicians to take advantage of the patient's remaining growth potential to guide craniofacial development and reduce the need for complex orthodontic procedures, extractions, or orthognathic surgery in adulthood. However, scientific literature shows ongoing debate regarding the optimal timing for intervention and the true magnitude of skeletal effects achieved with different functional appliances [5,16].

In Class II patients, the present study demonstrated a significant mandibular advancement and partial restriction of maxillary growth, resulting in improved sagittal relationships. These findings are consistent with previous studies reporting similar outcomes [8,17,18]. The increase in mandibular length (mean +6.02 mm) and improvement in SNB (+1.81°) were accompanied by a reduction in ANB and Wits values, confirming a more balanced maxillomandibular relationship. Similar results were reported by Khan et al. [8] and Xu et al [9].

At the dentoalveolar level, reductions in overjet (−3.9 mm) and overbite (−2.2 mm) were observed, indicating effective correction of upper incisor proclination and improvement of vertical occlusal relationships. These results align with previous reports supporting the efficacy of interceptive orthodontics during mixed dentition for the correction of developing malocclusions [5,8,9,17,19].

Regarding soft tissues, a significant retraction of the upper lip (−0.96 mm) and improved overall facial harmony were found, in agreement with earlier studies describing a more favorable facial profile following functional mandibular advancement and controlled maxillary growth [5,15].

In Class III patients, treatment with facemask therapy combined with rapid maxillary expansion produced favorable skeletal, dental, and soft-tissue outcomes. The results showed anterior–inferior stimulation of maxillary growth, accompanied by posterior and downward mandibular rotation, improving sagittal intermaxillary relationships (20–23). These findings are in line with existing evidence supporting facemask therapy as an effective means of maxillary protraction in growing patients.

At the dental level, mild proclination of upper incisors (+2.76°) and lower incisors (+1.64°) was observed, helping to restore a positive overjet and correct the anterior crossbite. This differs slightly from the findings of Souza et al. (23), who reported lower incisor retroclination when using skeletal anchorage with mini-screws.

In soft tissues, treatment resulted in a decrease in nasolabial angle (−2.66°) and a slight retraction of the lower lip (−0.75 mm), leading to conversion of the facial profile from concave to straight and improved overall facial balance in the middle and lower thirds.

Available evidence suggests that the effectiveness of early intervention lies in its ability to modulate skeletal growth and correct sagittal discrepancies at an early stage, achieving favorable clinical and aesthetic outcomes while reducing the need for future invasive procedures. However, this study also highlights the limitations of clear aligners as interceptive appliances. Despite their popularity due to comfort and aesthetics, their effects appear to be mainly dentoalveolar, with limited capacity to produce true skeletal changes [14,24,25]. In contrast, conventional functional appliances such as the Twin-Block, Herbst, and facemask demonstrate greater efficacy in orthopaedic modification of skeletal patterns.

Given the limitations of retrospective designs, future research should include randomized controlled trials with larger sample sizes and long-term follow-up to evaluate the stability of treatment outcomes. Incorporating three-dimensional (3D) imaging techniques, such as cone-beam computed tomography (CBCT), would also enhance the precision of measurements and provide more comprehensive assessment of craniofacial changes induced by interceptive appliances.

Further studies comparing the effects of different functional appliances (Twin-Block, Bionator, Herbst, facemask, chin cup, etc.) and analyzing the influence of sex and skeletal maturity stage on treatment response are also recommended.

Conclusions

The results of this study confirm that interceptive orthopaedic treatment during the growth phase produces significant skeletal, dental, and soft tissue improvements in both Class II and Class III malocclusions.

These improvements enhance facial aesthetics and occlusal function, thereby contributing to the overall quality of life of paediatric patients, reinforcing the importance of early, planned intervention.

Although the retrospective design of the present research represents a limitation, the findings support the clinical relevance of interceptive orthodontics as an effective strategy for guiding craniofacial development, reducing future treatment complexity, and minimizing the need for invasive procedures in adulthood.

Ethical Statements

Ethical approval

The study protocol was approved by the Ethics Committee of Universidad CEU San Pablo (Madrid, Spain) and conducted in accordance with the principles of the Declaration of Helsinki.

Informed consent

Written informed consent was obtained from the legal guardians of all participants prior to inclusion in the study.

Conflict of interest

The authors declare no conflicts of interest related to this work.

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