U.PORTO

FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

A comparative study of tooth-borne VS bone-borne anchorage in class III treatment of mixed dentition: a systematic review

Estudo comparativo do tratamento da Classe III em dentição mista com ancoragem dentária VS ancoragem esquelética: uma revisão sistemática

Perla Elena De Oliveira Velasquez

A thesis submitted to the Faculty of Dental Medicine of the University of Porto with the requirements for the integrated Master's degree in Dental Medicine

Porto 2023

U.PORTO

FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

A comparative study of tooth-borne VS bone-borne anchorage in class III treatment of mixed dentition: a systematic review

Author

Perla Elena De Oliveira Velasquez

5th year student of the Integrated Master's Degree in Dental Medicine

perla.eov.08@gmail.com

Thesis Supervisor

Prof. Doutor Eugénio Joaquim Pereira Martins

Assistant Professor of the Faculty of Dental Medicine of the University of Porto

Thesis Co-Supervisor

Prof. Doutora Maria João Feio Ponces Ramalhão

Assistant Professor of the Faculty of Dental Medicine of the University of Porto

ACKNOWLEDGMENTS

Ao Prof. Doutor Eugénio Martins,

Por me transmitir a sua paixão pela ortodontia desde o primeiro dia, pela constante motivação, dedicação, sentido prático com que sempre me orientou neste trabalho, e sobretudo, pela paciência.

À Prof. Doutora Maria João Ponces,

Por ter aceitado co-orientar a minha tese. Pelo encorajamento, disponibilidade, competência e todos os conhecimentos passados ao longo deste percurso.

Aos meus pais,

Por serem um exemplo e inspiração. Por estarem sempre presentes e pelo apoio incondicional. Graças a eles é que hoje estou aqui.

À minha irmã, Carla,

Por todos os momentos de cumplicidade e por me motivar dia após dia a ser uma pessoa melhor. Não desistas dos teus sonhos.

À minha binómia, Ana,

Por ter sido o meu braço direito nesta aventura, com quem aprendi muito e a quem também devo muito.

Aos meus amigos,

Que fizeram parte desta jornada, por me proporcionarem os melhores momentos e histórias que levo para a vida.

A todos vós, estarei eternamente agradecida.

“Caminante, no hay camino,
se hace camino al andar.
Al andar se hace el camino,
y al volver la vista atrás
se ve la senda que nunca
se ha de volver a pisar.”

Antonio Machado

ABSTRACT

Introduction: Skeletal class III malocclusion is a dentofacial anomaly that occurs due to an imbalance in the growth of the maxilla and mandible. In most cases, it is caused by maxillary deficiency. The conventional treatment for this condition is the tooth-borne facemask, which can result in undesirable dentoalveolar and skeletal consequences. To address these issues, skeletal anchorage has recently become an alternative for the early treatment of class III.

Objectives: The aim of this systematic review is to compare, using current literature, the effects of tooth-borne and bone-borne anchorage in the treatment of class III patients with mixed dentition.

Methods: A literature research was carried out in three databases, including PubMed, Scopus and Web of Science for studies published between 2013 and 2023 without language restrictions and using the PICO protocol to formulate the search strategy. Human retrospective or prospective non-randomized clinical trials in patients with class III malocclusion during the mixed dentition were included. The certainty of the evidence was assessed with the Newcastle-Ottawa scale.

Results: Of the 366 records identified from the initial search, 3 studies with a total of 87 patients were included. All the studies were of high certainty and low risk of bias. The two anchorage techniques showed improvements in SNA and ANB values, however these were not statistically significant. The effects of treatment on the SNB value showed a small variation.

Conclusions: The available evidence does not provide clear indications that bone-borne anchorage offers superior results compared to tooth-borne anchorage in the short-term for treating Class III patients with mixed dentition. No statistically significant differences were found between the two techniques in terms of their effectiveness. More high-certainty studies are needed for conclusive evidence.

Keywords: “Class III malocclusion”, “Skeletal Anchorage”, “Facemask”, “Extraoral Traction Appliances”, “Bone anchored maxillary protraction”, “Orthopaedic”, “Interceptive Treatment”.

RESUMO

Introdução: A má oclusão esquelética de Classe III é uma anomalia dentofacial que ocorre devido a um desequilíbrio no crescimento da maxila e mandíbula. Na maioria dos casos, ela é causada por deficiência maxilar. O tratamento convencional para esta condição é a máscara facial dento-suportada, que pode levar a indesejáveis consequências dentoalveolares e esqueléticas. Para resolver essas questões, a ancoragem esquelética tornou-se recentemente uma alternativa para o tratamento precoce da classe III.

Objetivos: O objetivo desta revisão sistemática é comparar, recorrendo a literatura atual, os efeitos da ancoragem dento-suportada e ósseo-suportada no tratamento de pacientes classe III em dentição mista.

Métodos: Foi realizada uma pesquisa de literatura em três bases de dados, incluindo a PubMed, Scopus e Web of Science, para estudos publicados entre 2013 e 2023, sem restrições de idioma, recorrendo ao protocolo PICO para formular a estratégia de pesquisa. Foram incluídos ensaios clínicos retrospetivos e prospetivos não randomizados em humanos, em pacientes com má oclusão classe III durante a dentição mista. A certeza da evidência foi avaliada com a escala Newcastle-Ottawa.

Resultados: Dos 366 artigos identificados na pesquisa inicial, 3 estudos com um total de 87 participantes foram incluídos. Todos os estudos apresentaram elevada certeza de evidência e baixo risco de viés. As duas abordagens de ancoragem mostraram melhorias nos valores de SNA e ANB, porém essas melhorias não foram estatisticamente significativas. Os efeitos do tratamento no valor de SNB mostraram ligeiras variações.

Conclusões: A evidência disponível não fornece indicações claras de que a ancoragem esquelética ofereça resultados superiores em comparação com a ancoragem dentária a curto prazo no tratamento de pacientes Classe III com dentição mista. Não foram encontradas diferenças estatisticamente significativas entre as duas técnicas em termos de efetividade. São necessários mais estudos de elevada certeza de evidência para evidências conclusivas.

Palavras-chave: “Má-oclusão Classe III”, “Ancoragem Esquelética”, “Máscara Facial”, “*Extraoral Traction Appliances”,* “Ortopédico”, “*Bone anchored maxillary protraction*”, “Tratamento Intercetivo”.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BAMP	Bone anchored maxillary protraction
CCTs	Controlled clinical trials
CVM	Cervical vertebral maturation
FM	Facemask
NOS	Newcastle-Ottawa Scale
PICO	Population, intervention, comparison, outcome
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCTs	Randomized controlled trials
RME	Rapid maxillary expansion
TADs	Temporary anchorage devices

1. INTRODUCTION

Skeletal class III malocclusion is a disorder with a multifactorial etiology resulting from the interaction between an individual's genetic susceptibility and environmental factors.[1] According to studies, the prevalence of Class III malocclusion varies across different ethnic groups. Among Caucasians, the incidence ranges from 1% to 5%; In Asian populations, the prevalence is reported to be around 14%. Among black individuals, the estimated prevalence ranges from 5% to 8%.[2, 3] The condition results from a discrepancy between the growth of the maxilla and mandible, which can manifest in various combinations of bony bases. This includes pure mandibular prognathism, a retrognathic or hypoplastic maxilla, or a combination of both.[4] According to Ellis and McNamara, maxillary deficiency represents almost two-thirds ($^2/_3$) of class III malocclusion cases.[5]

Class III malocclusion is considered a dentofacial anomaly that presents early manifestations, causing aesthetic and functional impairment to the patient. Unlike some other dental anomalies, this does not have a natural tendency to correct itself. Instead, it tends to worsen and become more noticeable during the pubertal growth spurt.[6, 7]

Early treatment of class III malocclusion in growing patients can be challenging due to factors such as the complexity of skeletal asymmetry, unpredictable mandibular growth pattern, determining the appropriate treatment timing, patient cooperation, and the risk of recurrence. Nevertheless, this approach can improve growth conditions and prevent the need for orthognathic surgery in the future or, at least, minimize the intensity of the given intervention, leading to a more stable and predictable outcome.[8, 9]

The facemask (FM), introduced by Delaire is a type of extra-oral appliance that has been widely recognized as the gold standard therapy for maxillary protraction in growing patients with maxillary deficiency, particularly in children aged 5 to 8 years (**Figure 1A)**.[10] It is often used in combination with rapid maxillary expansion (RME) as it enables the separation of the mid-palatal suture and remodels the surrounding of circumaxillary sutural systems, resulting in a greater forward movement of the maxilla, which is the primary goal of the treatment.[11, 12] A commonly used appliance is the Hyrax expander, a fixed

device bonded, or banded on the first permanent molars and first deciduous molars, or first premolars, and modified with hooks that allow attachment to the facemask (**Figure 1B,C)**.[13]

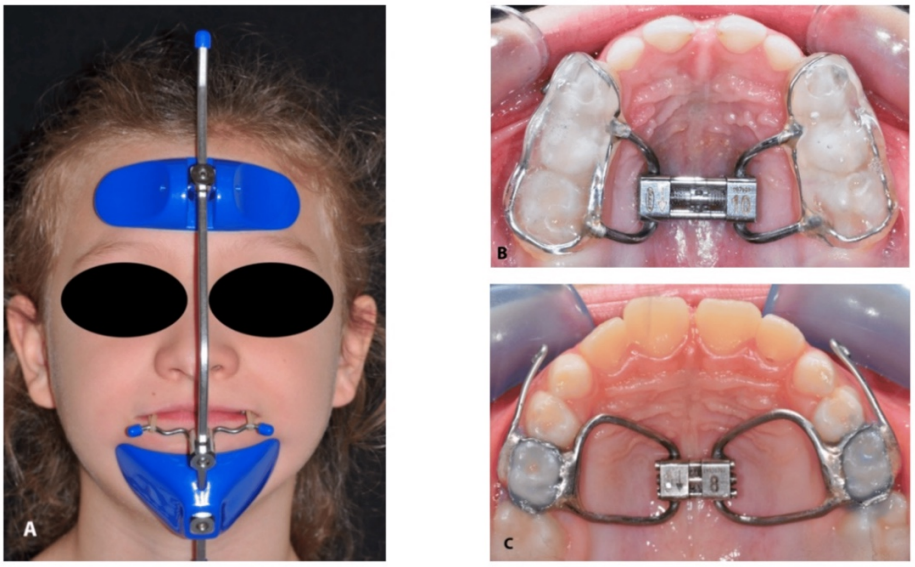

Figure 1. Conventional RME-Facemask treatment of Class III malocclusion **(A)** With bonded **(B)** or banded **(C)** Hyrax maxillary expander.

(Adapted from Giuntini *et al.* without the authors' permission)

In orthodontics, the concept of anchorage is based on Newton's third law, which states that every action has an equal and opposite reaction.[14] When orthodontic forces are applied to a tooth to achieve its desired movement, an opposite force of equal magnitude is produced on the neighboring teeth in the anchorage segment. This reactionary force can affect the neighboring teeth in the anchorage segment, potentially causing some displacement. However, by increasing the amount of anchorage in the area, the unwanted displacement can be minimized. Anchorage serves the purpose of resisting or completely suppressing these reactionary forces, ensuring that teeth are stable during orthodontic treatment.[15, 16] Two methods can be used for this purpose: tooth-borne (dental) anchorage, which relies on existing teeth as anchor points for orthodontic forces, and bone-borne (skeletal) anchorage, which involves the use of temporary anchorage devices (TADs), such as miniplates or mini-implants, inserted into the cortical bone, providing absolute anchorage.[16]

Tooth-borne maxillary protraction devices, such as the conventional RME-FM, apply indirect orthopedic forces to the maxilla through anchoring teeth. These traction forces are generated by elastics and can lead to undesired dentoalveolar and skeletal consequences, including mesialization and extrusion of the maxillary molars, contributing to posterior rotation of the mandible and an increase in vertical dimension of the face, proclination of the upper incisors, and retroclination of the mandibular incisors.[17, 18, 19]

In an attempt to overcome the limitations of conventional maxillary protraction with dental anchorage, skeletal anchorage has become a valuable alternative that allows the direct application of orthopedic forces to the maxilla and mandible, thus avoiding dental effects and improving skeletal outcomes.[20, 21] This procedure is recommended for children between the end of primary dentition and the beginning of permanent dentition, particularly before the age of 11/12.[22]

Over the years, several researchers have proposed different mechanisms of skeletal anchorage for the treatment of Class III malocclusion while simultaneously benefiting from the orthopedic effects of the facemask.[23] Kokich *et al.*[24] suggested a method involving intentionally ankylosing deciduous canines in the maxilla and using a facemask for maxillary protraction. Singer *et al.*[25] employed osseointegrated implants placed in the zygomatic buttress to achieve the desired results. Another approach by Hong *et al.*[26] involved the use of onplants on the palatal bone.[27]

Alternatively, with the promising outcomes of miniplates in achieving stable fixation of bony segments in maxillary surgery, the utilization of facemasks anchored to miniplates (**Figure 2A**) became a common practice.[28, 29, 30]

In a later work, De Clerck *et al.* [31] accomplished maxillary protraction using intermaxillary elastics. In this technique, known as bone-anchored maxillary protraction (BAMP), the intraoral class III elastics are connected to miniplates positioned on the infrazygomatic crests and mandibular symphysis (**Figure 2B**). This eliminates the need for the extraoral facemask and enables intermaxillary traction 24 hours a day.[32, 33]

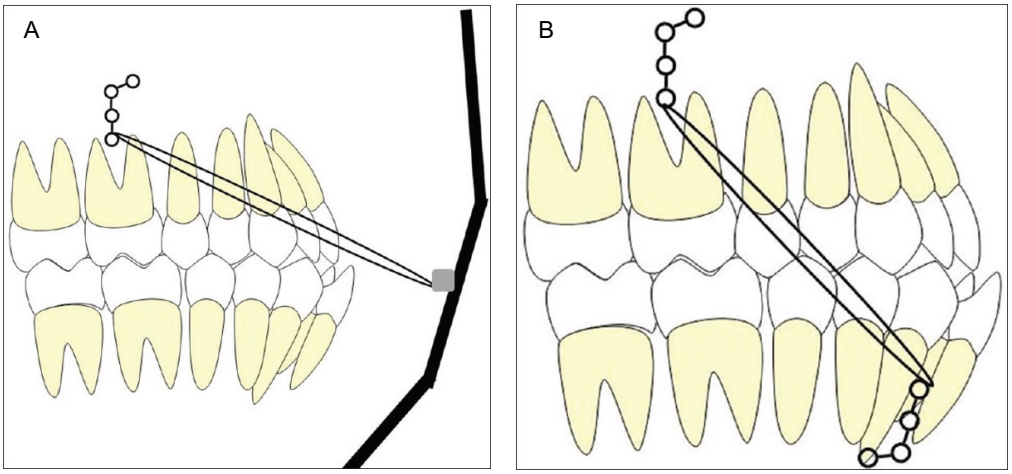

Figure 2. Schematic representation of the BAMP techniques.**(A)** Skeletal anchored facemask. **(B)** Intermaxillary elastics to miniplates.

(Adapted from Kamath *et al.* without the authors' permission)

There are three fundamental skeletal anchoring places for temporary anchorage devices in the maxilla used for facemask protraction: the lateral nasal walls, the maxillary zygomatic buttresses and the palate, this last involving the use of a hybrid expander anchored on two palatal miniscrews or a palatal plate, offering skeletal anchorage while the facemask provides extraoral force to protract the maxilla.[23]

In summary, regardless of the specific appliance used, whether it is the conventional tooth-borne orthopedic facemask, bone-borne, or tooth-bone-borne hybrid devices, a combination of these approaches, the primary goal of treatment for skeletal Class III malocclusion is to reduce the maxillary/mandibular discrepancy.

Recent studies have addressed the clinical outcomes and effectiveness of skeletal anchorage for the treatment of class III malocclusion, but they were done mostly on adolescents and growing patients during pubertal and post-pubertal stages.[23] Unfortunately, only a few clinical studies have compared the effects of tooth-borne and bone-borne anchorage in mixed dentition subjects (under 12 years old), before the onset of the pubertal growth spurt. Therefore, it is relevant to have current information regarding the efficacy of this therapeutic alternative in mixed dentition patients to contribute to a more informed and accurate therapeutic decision.

1.1 OBJECTIVES

The objective of this systematic review is to compare the effects of tooth-borne and bone-borne anchorage in the treatment of class III patients with mixed dentition.

To that end, three questions were formulated:

Q1: Does bone-borne anchorage techniques enhance the anteroposterior relationship of the maxilla and mandible?

Q2: Is the improvement in the anteroposterior position of the jaws statistically significant?

Q3: Do the improvements in the anteroposterior position vary depending on the technique used?

2. METHODOLOGY

The present systematic review was carried out in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations.[34]

2.1 ELIGIBILITY CRITERIA

The PICO strategy shown in **Table I** was adopted to establish the criteria to the study selection. The focused question presented in this systematic review was: “In Class III mixed dentition patients (P), does the treatment with skeletal anchorage (I) compared to dental anchorage (C) produce greater maxillary advancement (O)?”.

Table I. Description of PICO.

P (Population)	Class III patients in mixed dentition phase.
I (Intervention)	Class III treatment with skeletal anchorage.
C (Comparison)	Conventional RME-FM therapy or untreated patients.
O (Outcome)	Evaluation of cephalometric measurements related to the anteroposterior position of the maxilla and mandible.

Only the studies that met the eligibility criteria listed below were included in this systematic review.

Inclusion criteria:

(1) Human studies;
(2) Patients with Class III malocclusion during the mixed dentition phase (age $\geq$ 7 years to $\leq$ 12 years);

(3) Individuals who had received orthodontic treatment with skeletal anchorage;
(4) Cephalometric measures taken prior to and after treatment;
(5) Published between 2013 and 2023;
(6) Studies with a RME-FM and untreated group;
(7) Retrospective or prospective non-randomized clinical trials (CCTs).

Exclusion criteria:

(1) Patients older than 12 years;
(2) Patients with syndromic or cleft lip/palate conditions;
(3) Functional Class III malocclusion;
(4) Class I and/or Class II;
(5) Patients who had undergone surgery on the maxillofacial region;
(6) Previous orthodontic treatment.

2.2 INFORMATION SOURCES

A literature search was performed during April 2023 in three electronic databases: Pubmed, Scopus and Web of Science. The search was concluded in all databases on April 23, 2023.

2.3 SEARCH STRATEGY

The keywords or MeSH Terms used were: “Class III malocclusion”, “Skeletal Anchorage”, “Facemask” or “Mask”, “Extraoral Traction Appliances”, “Bone Anchored Maxillary Protraction”, “Orthopaedic” and “Interceptive Treatment”.

Articles published between 2013 and 2023 were considered and no language restriction was applied.

The search strategy was developed for PubMed and appropriately adapted for Scopus and Web of Science. The complete search protocol used for each database is shown in **Table II**.

Table II. Search Strategy.

	No.	Query	Results
PubMed	#1	"Malocclusion, Angle Class III"[Mesh]	1,621
	#2	Class III malocclusion	2,487
	#3	#1 OR #2	2,305
	#4	(Skeletal anchorage OR orthopaedic OR interceptive treatment OR bone anchored maxillary protraction)	325,135
	#5	(Extraoral Traction Appliances [Mesh] OR facemask OR mask)	30,501
	#6	#3 AND #4 AND #5	157
Scopus	#1	TITLE-ABS-KEY ("class III")	13,882
	#2	TITLE-ABS-KEY ("skeletal anchorage" OR orthopaedic OR "interceptive treatment" OR "bone anchored maxillary protraction")	103,271
	#3	TITLE-ABS-KEY (facemask OR mask)	82,586
	#4	#1 AND #2 AND #3	115
Web of Science	#1	TOPIC: (class III)	28,029
	#2	TOPIC: (skeletal anchorage) OR TOPIC: (bone anchored maxillary protraction)	1,013
	#3	TOPIC: (facemask) OR TOPIC: (mask)	102,814
	#4	#1 AND #2 AND #3	94

2.4 SELECTION PROCESS

In the first phase of the selection process, duplicates were removed using the “remove duplicates” tool from EndNote 20. The remaining studies were manually screened to ensure the removal of any additional duplicates. These studies were then screened based on the title and abstract according to the inclusion and exclusion criteria.

In the second phase, the full text of the studies was obtained whenever these criteria were met or when the information found in the abstract was unclear. Then, the remaining studies were read in their entirety, and their eligibility was assessed.

2.5 DATA COLLECTION PROCESS AND DATA ITEMS

For each included article, all relevant information was gathered, and the data were extracted and organized into **Table IV** to facilitate the comparison of characteristics among the included studies.

The following information were extracted:

(1) Author;
(2) Year of publication;
(3) Type of study;
(4) The participants: sample size, skeletal maturity method/stage, sex distribution and mean age of the patients in the study group and RME-FM/untreated group;
(5) Inclusion and exclusion criteria;
(6) The intervention: type of intervention and treatment duration;
(7) Main findings of the study.

2.6 CERTAINTY ASSESSMENT

The certainty of evidence of the studies included was assessed using the Newcastle-Ottawa Scale (NOS).[35] This tool determines the methodological certainty and risk of bias in non-randomized studies through a star scoring system ranging from 0 to a maximum of 9 stars. Each study was assessed using a questionnaire based on three categories: study group selection, comparability of groups and outcome of interest. The questionnaire can be found in the appendix A. Studies with a NOS score of 0 – 3 are classified as poor certainty and inherent high risk of bias, while those scoring between 4 – 6 are considered moderate certainty and studies scoring 7 – 9 are considered good certainty with a low risk of bias.[36]

3. RESULTS

3.1 STUDY SELECTION AND FLOW DIAGRAM

A comprehensive search identified 366 articles in total: 157 from the PubMed platform, 115 from Scopus, and 94 from Web of Science.

All research results were imported into EndNote 20 reference management software, and duplicate articles were removed. The program also served as storage for the studies and their respective full text.

Following the removal of 146 duplicates, 220 articles remained. Out of 220 articles, 201 were eliminated based on the title and abstract. Nineteen articles were selected for full text reading and their eligibility was assessed. The articles that did not meet the inclusion criteria were noted, and a table was made to provide a justification for their exclusion (**Table III**).

Table III. Excluded articles.

1st Author (year)	Exclusion reason
Aglarci *et al.* (2016)[32]	Age>12years
Bozkaya *et al.* (2017)[37]	Age>12years
Buyukcavus *et al.* (2020)[38]	Age>12years
Elganar *et al.* (2016)[39]	Age>12years
Lee, Y. S. *et al.* (2022)[40]	Age>12years
Seiryu *et al.* (2020)[41]	Age>12years
Nienkemper *et al.* (2013)[42]	Hybrid Hyrax
Nienkemper *et al.* (2015)[43]	Hybrid Hyrax
Nienkemper *et al.* (2016)[44]	Hybrid Hyrax
Tarraf *et al.* (2023)[18]	Hybrid Hyrax
Miranda *et al.* (2021)[45]	Hybrid Hyrax
Ngan *et al.* (2015)[22]	Hybrid Hyrax
Sar *et al.* (2014)[19]	Different RME protocol
Esenlik *et al.* (2019)[46]	No RME-FM or untreated group
Lee, S. H. *et al.* (2020)[20]	No RME-FM or untreated group
Hino *et al.* (2013)[47]	No cephalometric outcome

The selection process resulted in a total of three studies being included in this systematic review. The PRISMA 2020 flow chart (**Figure 3)** gives an overview of the selection process.

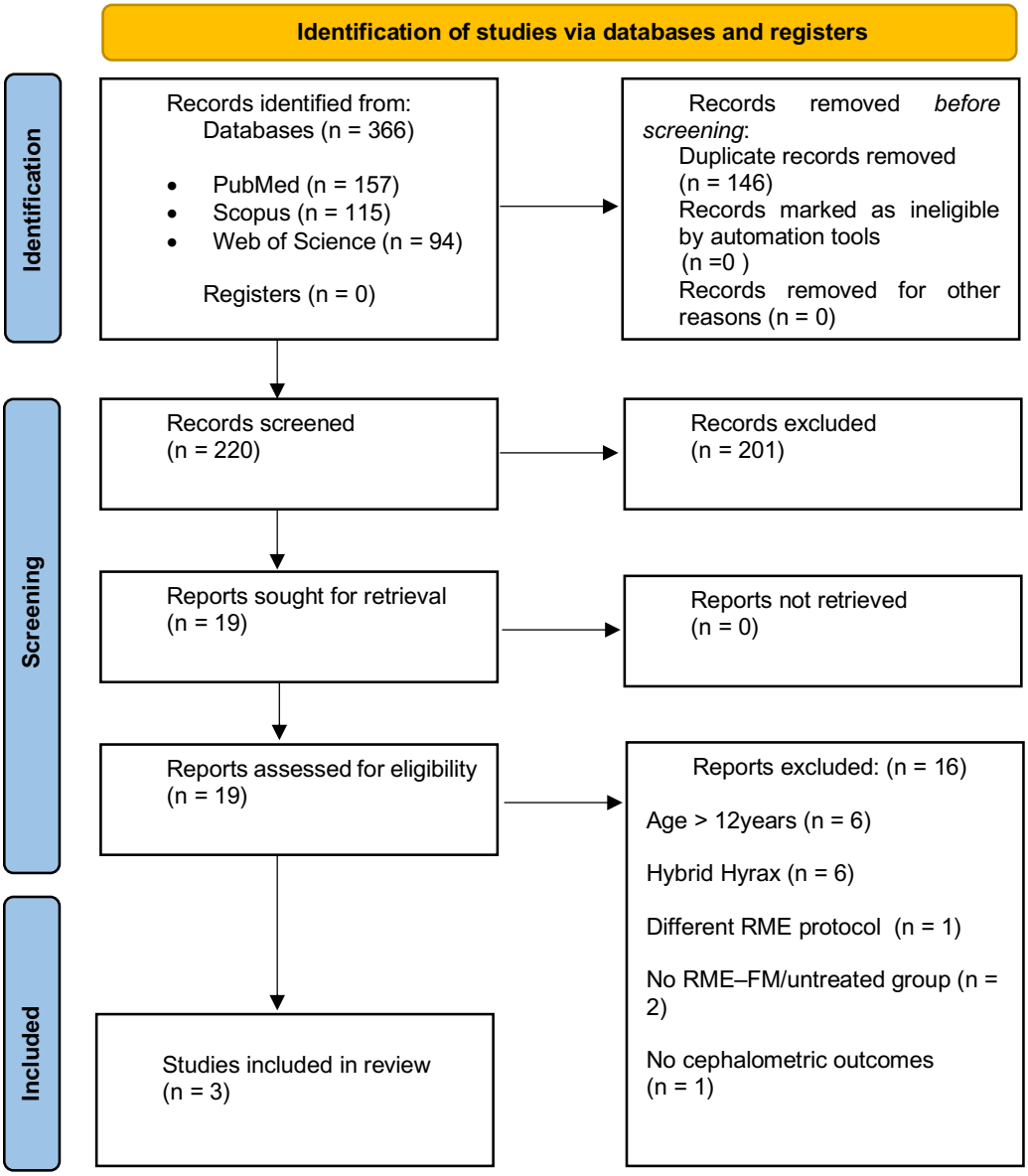

Figure 3. Study selection process with the PRISMA diagram flow.

(Adapted from Page *et al.*)

3.2 STUDY CHARACTERISTICS

3.2.1 TYPE OF STUDY

All three included articles were categorized as longitudinal studies. Among them, two were retrospective longitudinal controlled clinical trials[9, 48] and one was a prospective longitudinal controlled clinical trial[49].

These studies were conducted in different countries: Egypt[48], Brazil[49] and South Korea[9], and were published between 2016 and 2022.

The three studies performed cephalometric measurements before treatment, T0. However, only two performed measurements at the end of treatment, T1.[9, 49] One of the studies additionally performed measurements at T2, final observation after complete pubertal growth.[9] Therefore, for the purpose of this systematic review we did not consider the T2 measurement. A summary of the findings is provided in **Table IV**.

3.2.2 PARTICIPANTS

A total of 87 individuals within the age range of 7 to 12 years were included in the studies. All the studies provided information regarding the distribution of boys and girls in the experimental group and the comparison group. Only one study had a control group.[48]

De Souza *et al*.[49] and Lee *et al*.[9] used both inclusion and exclusion criteria, whereas the study conducted by Eid *et al*.[48] did not specify any exclusion criteria.

Two studies provided indications that the patients were still undergoing growth at T0, using different skeletal maturity methods: in the study by Eid *et al*.[48], cervical vertebral maturation assessment showed that patients were in a pre-pubertal and pubertal stage (CS 1 - CS 3). In the study by De Souza *et al*.[49], skeletal age assessment was based on carpal radiography. However, in the study by Lee *et al*.[9], the assessment of cervical vertebral maturation was mentioned only at T2. This assessment revealed that the patients at the final observation were in stage 5 or stage 6, which indicates the end of pubertal growth.

3.2.3 INTERVENTION

Two studies evaluated the efficacy of maxillary protraction with intermaxillary elastics: Eid *et al*.[48] evaluated the effect of maxillary protraction using intermaxillary elastics attached to four miniplates, following the BAMP protocol: two miniplates placed at the maxillary zygomatic buttresses and two in the mandible between the lateral incisors and canines. On the other hand, De Souza *et al*.[49] modified the BAMP protocol and evaluated the effect of maxillary protraction using intermaxillary elastics attached to four mini-implants: two placed in the mesial region of teeth 16 and 26 while the other two were positioned in the distal region of teeth 33 and 43. In the study, four patients presented lack of space between the roots of these involving teeth. As a result, in these specific cases, the mesial region was chosen for the placement of the mini-implants.

Lee *et al*.[9] evaluated the efficacy of facemask treatment with miniplates placed in the zygomatic buttress area.

In the study by Eid *et al*.[48] the control group did not receive any treatment. In the other two studies[9, 49] the comparison group received the conventional treatment, which involved the use of a facemask along with a rapid maxillary expander.

3.2.4 OUTCOMES EVALUATED

All included studies assessed the outcome measures through the analysis of lateral cephalometric radiographs, focusing on evaluating the skeletal, dentoalveolar and soft tissue effects. Eid *et al*.[48] analyzed 15 variables in both experimental and control group at T0 and T1 – T0. De Souza *et al*.[49] measured 11 common variables between the two groups at T0 – T1. Lee *et al*.[9] evaluated 19 variables across all time points (T0, T1 and T2). This systematic review considered three angular variables (SNA, SNB and ANB) from the included studies. Wits appraisal was not assessed in one of the studies, and therefore it was not included in this review.[48] **Table V** summarizes the outcome results for each study.

Table IV. Characteristics of the included studies.

Author (year)	Eid *et al.* (2016)[48]	De Souza *et al.* (2019)[49]	Lee, H. J. *et al.* (2022)[9]
Study design	CCT (Retrospective)	CCT (Prospective)	CCT (Retrospective)
Sample	20 subjects SA: 10 (5 F; 5 M) Co: 10 (3 F; 7 M)	24 subjects SA: 12 (8 F; 4 M) RME-FM: 12 (6 F; 6 M)	43 subjects SA: 20 (14 F; 6 M) RME-FM: 23 (15 F; 8 M)
Age	9 – 12 years	7 – 12 years	SA: 10.6 ± 1.1 years RME-FM: 10.0 ± 1.5 years
Skeletal maturity method/stage	CVM / CS 1-CS 3	Carpal radiography/prepubertal	–
Inclusion criteria	- Dentoskeletal Class III malocclusion with maxillary retrognathism (SNA <80°) - Pre-pubertal or pubertal stage (CS 1 – CS 3)	- Skeletal Class III (ANB <1°; Wits appraisal <2mm), - Straight or concave profile - Negative overjet incisor or end-to-end relationship - Before pre-pubertal growth spurt - Interradicular space for mini-implants placement	- FM therapy with RME appliances or miniplates as anchorage - Skeletal Class III malocclusion (anterior crossbite or edge-to-edge incisor relationship, Class III molar relationship, Wits appraisal of -2.5mm or less) - Lateral cephalograms before treatment (T0), after facemask therapy (T1) and final observation (T2)
Exclusion criteria	–	- Syndromes or systemic problems - Pseudo class III or muscle dysfunctions - Previous orthodontic treatment	- Prior orthopedic or orthodontic treatment - Craniofacial deformities - Poor compliance of patient - Cosmetic surgery
Type of intervention	SA: Intermaxillary elastics to miniplates (BAMP protocol) Co: No treatment	SA: Intermaxillary elastics to mini-implants RME-FM: Hyrax expander + facemask	SA: Maxillary miniplates to facemask (BAMP) RME-FM: Bonded or banded rapid maxillary expander + facemask
Treatment duration	SA: 12 months Co: observed for 1 year	SA:12.5 months RME-FM: 16 months	SA: 9.7 ± 0.3 months RME-FM: 9.0 ± 0.3 months
Main Findings	- BAMP induces a notable maxillary advancement, limits mandibular growth and enhances the facial profile of growing Class III patients.	- Mini-implants associated with intermaxillary elastics appear to be a reliable treatment option. - The use of mini-implants minimizes the adverse effects associated with the conventional treatment and leads to a shorter treatment time.	- Miniplate/FM treatment showed greater maxillary advancement compared to the RME-FM during the active treatment period. - The Miniplate/FM group demonstrated better preservation of the intermaxillary relationship following facemask therapy compared to the RME-FM group.

SA: skeletal (bone-borne) anchorage group; Co: control group; F: female; M: male; RME-FM: conventional (tooth-borne) treatment group.

Table V. Comparison of skeletal features at T0, T1 and T1–T0 between studies.

Cephalometric Measurements	Eid *et al.* (2016)[48]						De Souza *et al.* (2019)[49]						Lee, H. J. *et al.* (2022)[9]					
	SA			UNTREATED			SA			RME-FM			SA			RME-FM		
	T0 (Mean)	T1 (Mean)	T1–T0 (Mean)	T0 (Mean)	T1 (Mean)	T1–T0 (Mean)	T0 (Median)	T1 (Median)	T1–T0 (Median)	T0 (Median)	T1 (Median)	T1–T0 (Median)	T0 (Mean)	T1 (Mean)	T1–T0 (Mean)	T0 (Mean)	T1 (Mean)	T1–T0 (Mean)
SNA (º)	77.50	80.30	2.80	77.05	76.75	-0.30	84.00	86.75	2.25	80.00	83.00	3.00	77.40	80.50	3.10	79.20	81.30	2.10
SNB (º)	79.10	78.90	-0.20	80.00	81.90	1.90	83.00	83.75	0.75	82.00	82.77	0.77	79.30	78.00	-1.30	80.10	78.40	-1.70
ANB (º)	-2.00	1.40	3.40	-2.70	-3.45	-0.75	-1.00	1.50	2.00	-1.00	1.50	2.00	-1.80	2.50	4.40	-0.90	2.90	3.80

SA: skeletal anchorage group;
RME-FM: conventional (tooth-borne) treatment group;
T0: pre-treatment;
T1: end of treatment;
T1–T0: difference after–before treatment.
Normal values: SNA: 82º ± 2º; SNB: 80º ± 2º; ANB: 2º ± 2º.[50]

3.3 CERTAINTY OF EVIDENCE

Table VI summarizes the scores each study obtained in the certainty of evidence with the NOS. All three studies presented a high certainty, with a score of 7 or higher. The lowest score found was 7 points while the highest score was 9 points.

Table VI. Certainty assessment according to Newcastle-Ottawa Scale.

Study	Selection				Comparability		Outcome			
	1	2	3	4	a)	b)	1	2	3	Total score
Eid *et al.* (2016)[48]	★	-	★	★	★	-	★	★	★	7
De Souza *et al.* (2019)[49]	★	★	★	★	★	★	★	★	★	9
Lee, H. J. *et al.* (2022)[9]	★	★	★	★	★	-	★	★	★	8

★ The study addressed the evaluation abspect.

4. DISCUSSION

4.1 CONTEXT AND JUSTIFICATION OF WORK

The decision to focus on tooth-borne and bone-borne anchorage in the treatment of class III malocclusion during mixed dentition arose from the growing interest and use of skeletal anchorage devices in recent times. These devices have gained popularity in orthodontics, offering potential advantages for patients. Through a systematic review, we intended to evaluate the current body of literature and compare the effects of these two anchorage approaches. To achieve this objective, three research questions were formulated: “Does the use of bone-borne anchorage techniques lead to an enhancement in the anteroposterior relationship of the maxilla and mandible?”; “Is the improvement observed in the anteroposterior position of the jaws statistically significant?”; “Do the improvements in the anteroposterior position vary depending on the specific technique employed?”.

Alternative skeletal anchorage procedures have been investigated because of the limitations and drawbacks of the conventional treatment using a facemask. Although there are many case reports and clinical cases that describe the use of these procedures, there are surprisingly few recent studies that particularly investigate their usage in this particular patient population.

4.2 METHODOLOGY

The present systematic review was carried out following the PRISMA criteria. A comprehensive literature search was performed in three databases: PubMed, Scopus, and Web of Science, resulting in a total of 366 articles. After applying the eligibility criteria, 16 potentially relevant articles were excluded from the review. The reasons for their exclusion were as follows: some studies included participants over 12 years of age [32, 37, 38, 39, 40, 41]; certain studies used a hybrid hyrax appliance instead of a bone-borne device [18, 22, 42, 43, 44, 45]; variations in the

RME protocol were observed in one study[19]; two studies lacked a comparative group such as RME-FM or an untreated group[20, 46]; and one study did not assess outcomes through cephalometric analysis[47]. Finally, three studies met the eligibility criteria established for this review. After assessing the certainty of evidence using the NOS, all three studies demonstrated a high level of certainty and a low risk of bias.

4.3 MAIN OUTCOMES

The analysis of the collected data from the included studies indicates that patients who are suitable candidates for skeletal anchorage treatment of Class III malocclusion should exhibit certain characteristics. These include having a skeletal Class III malocclusion, a retruded maxila (SNA < 80°), an anterior crossbite or an edge-to-edge incisor relationship, and a skeletal Class III tendency (ANB < 1°).

Despite the inclusion of skeletal, dentoalveolar, and soft tissue outcomes in all three studies, we were only able to rely on the common cephalometric measurement parameters to facilitate comparisons. As a result, only skeletal outcomes were taken into consideration in this review, specifically considering three angular variables: SNA (sagittal relationship of the maxilla with the base of the skull), SNB (sagittal relationship of the mandible with the base of the skull), and ANB (sagittal discrepancy between the maxilla and mandible).

4.4 RESULTS

Regarding the anteroposterior maxillary position (SNA):

Eid *et al*.[48] conducted a comparison between a SA group and a control group of untreated patients. Prior to treatment (T0), no statistically significant differences (*P*=0.612) were observed between the two groups, indicating that both groups exhibited similar clinical features at the beginning of the study. At this time point, the SA group presented an SNA value of 77.50º and the control group

an SNA value of 77.05º. However, after one year of treatment (T1-T0), a significant difference (*P* ≤0.001) was observed between the groups. The SA group showed changes of 2.80º, indicating improvement in the anteroposterior maxillary position, while the untreated group showed changes of -0.30º, suggesting exacerbation of retrognathia or no changes in the anteroposterior maxillary position.

De Souza *et al*.[49] and Lee *et al*.[9] conducted comparisons between the skeletal anchorage group (SA) and conventional treatment group (RME-FM) at T1-T0 to assess the differences observed before and after treatment.

In the study conducted by De Sousa *et al.*[49], no statistically significant differences (*P*=0.051) were observed between the SA and RME-FM groups at the initial time point (T0). The SA group had a median SNA value of 84.00º, while the RME-FM group had a median SNA value of 80.00º at this time point. At the end of the treatment, both groups showed a significant increase in SNA values. De Souza *et al*.[49] reported changes of 2.25º and 3.00º in the SA and RME-FM groups, respectively. However, when comparing the two treatment approaches, no statistically significant differences (*P*=0.779) were found. These findings suggest that the skeletal anchorage and conventional treatment approaches led to improved anteroposterior maxillary position.

According to Lee *et al.*[9], at the initial time point (T0), the two groups did not show significant differences in the dentoskeletal characteristics, except for the cephalometric parameters SNA and Wits appraisal (*P*=0.032). The SNA value was higher in the RME-FM group compared to the SA group: 77.40º in the SA group and 79.20º in the RME-FM group. After the treatment (T1-T0), a change of 3.10º in the SNA value was observed in the SA group, while the RME-FM group showed a change of 2.10º. These results indicated a statistically significant difference (*P* =0.024) between the two treatment techniques. This increase in the SNA value in the SA group (3.10º) can be attributed to the use of a skeletal anchored facemask, as this treatment approach enables the direct application of forces to the circumaxillary sutures, in contrast to the conventional tooth-borne facemask and other bone-borne techniques.[9] When comparing this SNA value (3.10º) with the one obtained in the RME-FM group by De Souza (3.00º), it suggests that there may not be clinically significant differences between the two

approaches. Therefore, the invasiveness of the procedure should be taken into consideration when choosing the appropriate appliance.

Regarding the anteroposterior mandibular position (SNB):

In the study by Eid *et al.*[48], at the pre-treatment time point (T0), no statistically significant differences (*P*=0.218) were found between the SA group and the untreated group, with SNB values of 79.10º and 80.00º, respectively. At the end of the treatment, the results showed statistically significant differences (*P*≤0.001) between the SA group and the untreated group, with a decrease in the SNB value in the SA group (-0.20º) and an increase in this value in the untreated group (1.90º). The untreated group tends to experience an aggravation of mandibular protrusion, as evidenced by the increase in the SNB value, suggesting a forward movement or advancement of the mandible in the untreated group during the observation period. In contrast, when evaluating the SA group, Eid *et al*.[48] observed improvements in mandibular positioning. This indicates a positive change in the mandibular position following treatment with skeletal anchorage.

De Souza *et al*.[49] and Lee *et al*.[9] compared the skeletal anchorage group (SA) with the conventional treatment group (RME-FM). However, neither of the authors found statistically significant results in the observed changes before and after treatment.

In the study conducted by De Sousa *et al.*[49], no statistically significant differences (*P*=0.061) were found between the SA and RME-FM groups at the initial time point (T0). At this time point, the SA group had a median SNB value of 83.00º, while the RME-FM group had a median SNB value of 82.00º. There were no statistically significant differences observed between the two treatment approaches as well. After the treatment, a slight increase in the SNB value was observed in both groups. The SA group had an SNB value of 83.75º, while the RME-FM group had an SNB value of 82.77º.

In the study conducted by Lee *et al.*[9], no statistically significant differences (*P*=0.394) were found between the SA and RME-FM groups at the pre-treatment stage. At this stage, the SA group had an average value of 79.30º, while the RME-FM group had an average value of 80.10º. Similarly, after the treatment, no

statistically significant differences (*P*=0.218) were observed between the two treatment techniques, as the changes that occurred in the period from T0 to T1 were -1.30º in the SA group and -1.70º in the RME-FM group. Since in this study both groups use facemask, whether it is skeletal anchored or conventional tooth-borne, it is believed that the decrease of the SNB angle may be attributed to the clockwise rotation of the mandible, which is a characteristic of facemask treatment.[31]

Regarding the anteroposterior jaw relationship (ANB):

In the study by Eid *et al.*[48], initially at T0, no statistically significant differences were observed between the two groups, indicating that both groups had similar clinical features at the beginning of the study. However, in T1-T0, the results showed a statistically significant difference (*P*≤0.001) between the group treated with skeletal anchorage and the untreated group. In the skeletal anchorage group, the ANB value improved (-2.00º to 1.40º), while in the control group of untreated patients, the ANB value increased (-2.70º to -3.45º), indicating a worsening of the maxillomandibular discrepancy in those individuals.

In the study by De Sousa *et al.*[49], no statistically significant differences (*P*=0.458) were observed at the initial time point (T0), indicating that both the SA group and the RME-FM group presented an ANB value of -1.00º. When comparing the results obtained in T1-T0, both groups showed an increase in ANB values, with the SA group showing an increase of 2.00º and the RME-FM group also showing an increase of 2.00º. However, the increase in both groups was not statistically significant (*P*=0.978).

In the study by Lee *et al.*[9], no statistically significant differences (*P*=0.071) were observed at the initial time point (T0), with the SA group having an ANB value of -1.8º and the RME-FM group having an ANB value of -0.90º. The results indicate that there are no statistically significant differences (*P*=0.218) between the two groups after treatment (T1-T0), as the SA group showed an increase of 4.40º in the ANB value and the RME-FM group showed an increase of 3.80º.

In all treated groups, an increase in the ANB angle was observed at T1-T0, indicating an improvement in the maxillomandibular relationship, and bringing the

patients closer to a skeletal Class I condition. However, these changes were not found to be statistically significant when comparing the SA and RME-FM groups.

4.5 STUDY LIMITATIONS

This systematic review comprised three studies, which exhibited some differences. Two of the studies compared the treatment effects of skeletal anchorage with the conventional treatment in class III patients during the mixed dentition phase. However, variations were observed in the reporting of outcome measures. De Souza *et al*.[49] presented the outcome measures as median values, while Lee *et al*.[9] presented them as mean values. This discrepancy in reporting methods made it challenging to directly compare the results. Only one study[48] included a control group, so the outcomes observed in the other two studies[9, 49] do not take into account natural growth.

Only a few (three) studies were included, all of which were longitudinal clinical trials. More up to date RCTs related to this topic are needed to assess the treatment outcomes in class III patients during the mixed dentition phase.

Another limitation is that the total sample size was small, consisting of only 87 patients. On the other hand, the variability in protocols implemented among the different studies, as the inclination of the elastics to the occlusal plane, along with variations in the type of temporary anchorage devices and maxillary expansion devices used, could potentially affect the final results.

5. CONCLUSIONS

The present systematic review showed that:

- The SNA, SNB, and ANB values showed statistically significance and favorable outcomes in untreated patients who underwent either treatment approaches;

- Significant improvements were seen for the SNA value with both treatment approaches;

- Variations in the SNB value were observed, ranging from -1.70º to 0.77º;

- When comparing the ANB value, both techniques showed improvements in the maxillomandibular relationship, bringing the patients closer to a skeletal Class I condition;

- The available evidence does not provide clear indications that bone-borne anchorage (skeletal anchorage) offers superior results compared to tooth-borne anchorage (conventional RME-FM treatment) in the short-term for treating Class III patients with mixed dentition, as no statistically significant differences were found between the two techniques in terms of their effectiveness;

- More high-certainty studies, preferably RCTs, are needed for conclusive evidence.

6. BIBLIOGRAPHY

1. Litton SF, Ackermann LV, Isaacson RJ, Shapiro BL. A genetic study of Class 3 malocclusion. Am J Orthod. 1970;58(6):565-77.

2. Poletti L, Silvera AA, Ghislanzoni LT. Dentoalveolar class III treatment using retromolar miniscrew anchorage. Prog Orthod. 2013;14:7.

3. Zere E, Chaudhari PK, Sharan J, Dhingra K, Tiwari N. Developing Class III malocclusions: challenges and solutions. Clin Cosmet Investig Dent. 2018;10:99-116.

4. De Toffol L, Pavoni C, Baccetti T, Franchi L, Cozza P. Orthopedic treatment outcomes in Class III malocclusion. Angle Orthod. 2008;78(3):561-73.

5. Ellis E, III, McNamara JA, Jr. Components of adult class III malocclusion. J Oral Maxillofac Surg. 1984;42(5):295-305.

6. Baccetti T, Franchi L, McNamara J. Growth in the Untreated Class III Subject. Semin Orthod. 2007;13:130-42.

7. Baccetti T, McGill JS, Franchi L, McNamara JA, Jr., Tollaro I. Skeletal effects of early treatment of Class III malocclusion with maxillary expansion and face-mask therapy. Am J Orthod Dentofacial Orthop. 1998;113(3):333-43.

8. Westwood PV, McNamara JA, Jr., Baccetti T, Franchi L, Sarver DM. Long-term effects of Class III treatment with rapid maxillary expansion and facemask therapy followed by fixed appliances. Am J Orthod Dentofacial Orthop. 2003;123(3):306-20.

9. Lee HJ, Choi DS, Jang I, Cha BK. Comparison of facemask therapy effects using skeletal and tooth-borne anchorage: A longitudinal retrospective study. Angle Orthod. 2022;92(3):307-14.

10. Delaire J. [Manufacture of the "orthopedic mask"]. Rev Stomatol Chir Maxillofac. 1971;72(5):579-82.

11. Maspero C, Galbiati G, Perillo L, Favero L, Giannini L. Orthopaedic treatment efficiency in skeletal Class III malocclusions in young patients: RME-face mask versus TSME. European journal of paediatric dentistry : official journal of European Academy of Paediatric Dentistry. 2012;13:225-30.

12. Maspero C, Galbiati G, Giannini L, Farronato G. Sagittal and vertical effects of transverse sagittal maxillary expander (TSME) in three different malocclusion groups. Prog Orthod. 2015;16:6.

13. Agarwal A, Mathur R. Maxillary Expansion. Int J Clin Pediatr Dent. 2010;3(3):139-46.

14. Young KA, Melrose CA, Harrison JE. Skeletal anchorage systems in orthodontics: absolute anchorage. A dream or reality? J Orthod. 2007;34(2):101-10.

15. Sugawara J. Temporary skeletal anchorage devices: the case for miniplates. Am J Orthod Dentofacial Orthop. 2014;145(5):559-65.

16. Costello BJ, Ruiz RL, Petrone J, Sohn J. Temporary skeletal anchorage devices for orthodontics. Oral Maxillofac Surg Clin North Am. 2010;22(1):91-105.

17. Wu Z, Zhang X, Li Z, Liu Y, Jin H, Chen Q, et al. A Bayesian network meta-analysis of orthopaedic treatment in Class III malocclusion: Maxillary protraction with skeletal anchorage or a rapid maxillary expander. Orthodontics and Craniofacial Research. 2020;23(1):1-15.

18. Tarraf NE, Dalci O, Dalci K, Altug AT, Darendeliler MA. A retrospective comparison of two protocols for correction of skeletal Class III malocclusion in prepubertal children: hybrid hyrax expander with mandibular miniplates and rapid maxillary expansion with face mask. Prog Orthod. 2023;24(1).

19. Sar C, Sahinoglu Z, Ozcirpici AA, Uckan S. Dentofacial effects of skeletal anchored treatment modalities for the correction of maxillary retrognathia. Am J Orthod Dentofacial Orthop. 2014;145(1):41-54.

20. Lee SH, Koh SD, Chung DH, Lee JW, Lee SM. Comparison of skeletal anchorage and tooth-borne maxillary protraction followed by fixed appliance in Class III malocclusion. Eur J Orthod. 2020;42(2):193-9.

21. Liang S, Wang F, Chang Q, Bai Y. Three-dimensional comparative evaluation of customized bone-anchored vs tooth-borne maxillary protraction in patients with skeletal Class III malocclusion. Am J Orthod Dentofacial Orthop. 2021;160(3):374-84.

22. Ngan P, Wilmes B, Drescher D, Martin C, Weaver B, Gunel E. Comparison of two maxillary protraction protocols: tooth-borne versus bone-anchored protraction facemask treatment. Prog Orthod. 2015;16.

23. Rutili V, Nieri M, Franceschi D, Pierleoni F, Giuntini V, Franchi L. Effects produced by the facemask with and without skeletal anchorage for the orthopaedic treatment of Class III malocclusion in growing patients: a systematic review and meta-analysis of RCTs. Eur J Orthod. 2023;45(2):157-68.

24. Kokich VG, Shapiro PA, Oswald R, Koskinen-Moffett L, Clarren SK. Ankylosed teeth as abutments for maxillary protraction: a case report. Am J Orthod. 1985;88(4):303-7.

25. Singer SL, Henry PJ, Rosenberg I. Osseointegrated implants as an adjunct to facemask therapy: a case report. Angle Orthod. 2000;70(3):253-62.

26. Hong H, Ngan P, Han G, Qi LG, Wei SH. Use of onplants as stable anchorage for facemask treatment: a case report. Angle Orthod. 2005;75(3):453-60.

27. Koh S-D, Chung DH. Comparison of skeletal anchored facemask and tooth-borne facemask according to vertical skeletal pattern and growth stage. The Angle Orthodontist. 2013;84(4):628-33.

28. Cha B-K, Lee N-K, Choi D-S. Maxillary protraction treatment of skeletal Class III children using miniplate anchorage. Korean Journal of Orthodontics. 2007:73-84.

29. Lee N-K, Yang I-H, Baek S-H. The short-term treatment effects of face mask therapy in Class III patients based on the anchorage device: miniplates vs rapid maxillary expansion. The Angle Orthodontist. 2012;82(5):846-52.

30. Kamath A, Sudhakar SS, Kannan G, Rai K, Sb A. Bone-anchored maxillary protraction (BAMP): A review. J Orthod Sci. 2022;11:8.

31. De Clerck H, Nguyen T, de Paula LK, Cevidanes L. Three-dimensional assessment of mandibular and glenoid fossa changes after bone-anchored Class III intermaxillary traction. Am J Orthod Dentofacial Orthop. 2012;142(1):25-31.

32. Aglarci C, Esenlik E, Findik Y. Comparison of short-term effects between face mask and skeletal anchorage therapy with intermaxillary elastics in patients with maxillary retrognathia. Eur J Orthod. 2016;38(3):313-23.

33. Esenlik E, Aglarci C, Albayrak GE, Findik Y. Maxillary protraction using skeletal anchorage and intermaxillary elastics in Skeletal Class III patients. Korean Journal of Orthodontics. 2015;45(2):95-101.

34. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.

35. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Oxford; 2000.

36. Luchini C, Stubbs B, Solmi M, Veronese N. Assessing the quality of studies in meta-analyses: Advantages and limitations of the Newcastle Ottawa Scale. World Journal of Meta-Analysis. 2017;5(4):80-4.

37. Bozkaya E, Yüksel AS, Bozkaya S. Zygomatic miniplates for skeletal anchorage in orthopedic correction of class III malocclusion: A controlled clinical trial. Korean Journal of Orthodontics. 2017;47(2):118-29.

38. Buyukcavus MH, Kale B, Aydemir B. Comparison of treatment effects of different maxillary protraction methods in skeletal class III patients. Orthod Craniofac Res. 2020;23(4):445-54.

39. Elnagar MH, Elshourbagy E, Ghobashy S, Khedr M, Evans CA. Comparative evaluation of 2 skeletally anchored maxillary protraction protocols. Am J Orthod Dentofacial Orthop. 2016;150(5):751-62.

40. Lee YS, Park JH, Kim J, Lee NK, Kim Y, Kook YA. Treatment effects of maxillary protraction with palatal plates vs conventional tooth-borne anchorage in growing patients with Class III malocclusion. Am J Orthod Dentofacial Orthop. 2022;162(4):520-8.

41. Seiryu M, Ida H, Mayama A, Sasaki S, Sasaki S, Deguchi T, et al. A comparative assessment of orthodontic treatment outcomes of mild skeletal Class III malocclusion between facemask and facemask in combination with a miniscrew for anchorage in growing patients: A single-center, prospective randomized controlled trial. Angle Orthod. 2020;90(1):3-12.

42. Nienkemper M, Wilmes B, Pauls A, Drescher D. Maxillary protraction using a hybrid hyrax-facemask combination. Prog Orthod. 2013;14(1):1-8.

43. Nienkemper M, Wilmes B, Franchi L, Drescher D. Effectiveness of maxillary protraction using a hybrid hyrax-facemask combination: A controlled clinical study. Angle Orthod. 2015;85(5):764-70.

44. Nienkemper M, Wilmes B, Pauls A, Drescher D. Maxillary Protraction Using a Hybrid Hyrax-Facemask Combination. Informationen Aus Orthodontie Und Kieferorthopaedie. 2016;48(4):221-7.

45. Miranda F, Cunha Bastos JCD, Magno Dos Santos A, Janson G, Pereira Lauris JR, Garib D. Dentoskeletal comparison of miniscrew-anchored maxillary protraction with hybrid and conventional hyrax expanders: A randomized clinical trial. Am J Orthod Dentofacial Orthop. 2021;160(6):774-83.

46. Esenlik E, Albayrak GE, Ağlarcı C, Coşkun EY, Fındık Y, Orhan H. Evaluation of skeletally anchored therapy using miniplates and micro-implants in skeletal class iii treatment. Australasian Orthodontic Journal. 2019;35(2):158-66.

47. Hino CT, Cevidanes LH, Nguyen TT, De Clerck HJ, Franchi L, McNamara JA, Jr. Three-dimensional analysis of maxillary changes associated with facemask and rapid maxillary expansion compared with bone anchored maxillary protraction. Am J Orthod Dentofacial Orthop. 2013;144(5):705-14.

48. Eid OM, Ramadan AAF, Nadim MA, Hamed TAB. Maxillary protraction using orthodontic miniplates in correction of Class III malocclusion during growth. Journal of the World Federation of Orthodontists. 2016;5(3):100-6.

49. de Souza RA, Rino Neto J, de Paiva JB. Maxillary protraction with rapid maxillary expansion and facemask versus skeletal anchorage with mini-implants in class III patients: a non-randomized clinical trial. Prog Orthod. 2019;20(1).

50. Cobourne MT, DiBiase AT. Handbook of orthodontics. Edinburgh: Elsevier Edinburgh; 2016.

51. Giuntini V, Camporesi M, Barone V, Marino Merlo M, Nardi C, Franceschi D, et al. Postpubertal Effects of the Rapid Maxillary Expansion and Facial Mask versus the Removable Mandibular Retractor for the Early Treatment of Class III Malocclusion: A Study on Lateral Cephalograms. Applied Sciences. 2021;11(18):8393.

7. APPENDIX

APPENDIX A

Newcastle-Ottawa Quality Assessment Form for Cohort Studies

Note: A study can be given a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability.

Selection

1) Representativeness of the exposed cohort
    a) Truly representative ***(one star)***
    b) Somewhat representative ***(one star)***
    c) Selected group
    d) No description of the derivation of the cohort
2) Selection of the non-exposed cohort
    a) Drawn from the same community as the exposed cohort ***(one star)***
    b) Drawn from a different source
    c) No description of the derivation of the non-exposed cohort
3) Ascertainment of exposure
    a) Secure record (e.g., surgical record) ***(one star)***
    b) Structured interview ***(one star)***
    c) Written self-report
    d) No description
    e) Other
4) Demonstration that outcome of interest was not present at start of study
    a) Yes ***(one star)***
    b) No

Comparability

1) Comparability of cohorts on the basis of the design or analysis controlled for confounders
    a) The study controls for age, sex and marital status ***(one star)***
    b) Study controls for other factors (list) _____ ***(one star)***
    c) Cohorts are not comparable on the basis of the design or analysis controlled for confounders

Outcome

1) Assessment of outcome
    a) Independent blind assessment ***(one star)***
    b) Record linkage ***(one star)***
    c) Self report
    d) No description
    e) Other
2) Was follow-up long enough for outcomes to occur
    a) Yes ***(one star)***
    b) No
3) Adequacy of follow-up of cohorts
    a) Complete follow up- all subject accounted for ***(one star)***
    b) Subjects lost to follow up unlikely to introduce bias- number lost less than or equal to 20% or description of those lost suggested no different from those followed. ***(one star)***
    c) Follow up rate less than 80% and no description of those lost
    d) No statement

APPENDIX B

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

DECLARAÇÃO

Mestrado Integrado em Medicina Dentária
Monografia/Relatório de Estágio

Identificação do Autor

Nome completo: Perla Elena De Oliveira Velasquez

Nº identificação civil: 14857169 **Nº de estudante**: 201903495

Email institucional: up201903495@up.pt
Email alternativo: perla.eov.08@gmail.com **Tlm**: 963968847

Faculdade/Instituto: Faculdade de Medicina Dentária da Universidade do Porto

Identificação da Publicação

Dissertação de Mestrado Integrado (Monografia) ☒ Relatório de Estágio ☐

Título Completo: "A comparative study of tooth-borne VS bone-borne anchorage in class III treatment of mixed dentition: a systematic review"

Orientador: Eugénio Joaquim Pereira Martins
Coorientador: Maria João Feio Ponces Ramalhão

Palavras-Chave: "Class III malocclusion", "Skeletal Anchorage", "Facemask", "Extraoral Traction Appliances", "Bone anchored maxillary protraction", "Orthopaedic", "Interceptive Treatment".

Autorizo a disponibilização imediata do texto integral no Repositório da U.Porto: _____

Não autorizo a disponibilização imediata do texto integral no Repositório da U.Porto:_____

Autorizo a disponibilização do texto integral no Repositório da U.Porto, com período de embargo, no prazo de:

6 meses: ___; 12 meses: ___; 18 meses: _X_; 24 meses: ___; 36 meses: ___; 120 meses: ___; Justificação para a não autorização imediata: Publicação em revista.

Data:03/07/2023.

Assinado por: **PERLA ELENA DE OLIVEIRA VELASQUEZ**
Num. de Identificação: 14857169
Data: 2023.07.03 17:22:14+01'00'

Assinatura: _____

CARTÃO DE CIDADÃO

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

PARECER DO ORIENTADOR

Informo que o Trabalho de Monografia desenvolvido pela estudante Perla Elena De Oliveira Velasquez do 5° ano do Curso de Mestrado Integrado em Medicina Dentária da Faculdade de Medicina Dentária da Universidade do Porto, com o título: “A comparative study of tooth-borne VS bone-borne anchorage in class III treatment of mixed dentition: a systematic review” está de acordo com as regras estipuladas na FMDUP, foi por mim conferido e encontra-se em condições de ser apresentado em provas públicas.

Porto, 3 de Julho de 2023.

Assinado por: Eugénio Joaquim Pereira Martins
Identificação: BI08129161
Data: 2023-07-03 às 15:14:21
Local: porto
Motivo: Validar Parecer

_____

Eugénio Joaquim Pereira Martins

APPENDIX D

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

PARECER DO COORIENTADOR

Informo que o Trabalho de Monografia desenvolvido pela estudante Perla Elena De Oliveira Velasquez do 5° ano do Curso de Mestrado Integrado em Medicina Dentária da Faculdade de Medicina Dentária da Universidade do Porto, com o título: “A comparative study of tooth-borne VS bone-borne anchorage in class III treatment of mixed dentition: a systematic review” está de acordo com as regras estipuladas na FMDUP, foi por mim conferido e encontra-se em condições de ser apresentado em provas públicas.

Porto, 3 de Julho de 2023.

A Coorientadora,

Assinado por: **Maria João Feio Ponces Ramalhão**
Num. de Identificação: 07277120
Data: 2023.07.03 18:57:54 +0100

CHAVE MÓVEL

Maria João Feio Ponces Ramalhão

APPENDIX E

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

DECLARAÇÃO

Monografia/Relatório de Estágio

Declaro que o presente trabalho, no âmbito da Monografia/Relatório de Estágio, integrado no MIMD, da FMDUP, é da minha autoria e todas as fontes foram devidamente referenciadas.

Porto, 3 de Julho de 2023.

Assinado por: **PERLA ELENA DE OLIVEIRA VELASQUEZ**
Num. de Identificação: 14857169
Data: 2023.07.03 17:25:14+01'00'

CARTÃO DE CIDADÃO

Perla Elena De Oliveira Velasquez

U.PORTO

FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

PARECER DO ORIENTADOR

Declaro que o estudante Perla Elena de Oliveira Velasquez do 5° ano do Curso de Mestrado Integrado em Medicina Dentária da Faculdade de Medicina Dentária da Universidade do Porto, entregou a versão final do seu trabalho de Monografia intitulado: “A comparative study of tooth-borne VS bone-borne anchorage in class III treatment of mixed dentition: a systematic review”, com todas as alterações por mim aceites, discriminadas em errata apresentada durante o ato de provas públicas realizadas no dia 13 de Setembro.

Porto, 20 de Setembro de 2023.

Assinado por: Eugénio Joaquim Pereira Martins
Identificação: BI08129161
Data: 2023-09-20 às 22:13:42
Local: mirandela
Motivo: Validar Parecer

_____

Eugénio Joaquim Pereira Martins