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Association between control of vertical dimension in orthodontics and orthopedic treatment: a systematic review

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Transverse maxillary discrepancy, mandibular skeletal retrusion, and increased lower anterior face height have been recognized as frequent abnormalities in growing individuals, despite the paucity of available data. **Aim:** This research looked at the relationship between treatment planning and Control of Vertical Dimension (CVD) effectiveness in orthopaedic and orthodontic therapy (OT). **Methods:** We searched full-text publications in PubMed, Web of Science, Scopus, Embase, Google Scholar, and ScienceDirect databases from 1970 to 2024. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) quality scale was used for the critical selection of the studies. **Results:** We identified 43 articles, of which 28 were included in the review. Also observed that a strong and positive relation was established for the two parameters of CVD and OT for both growing subjects. **Conclusion:** We can suggest from our study that rapid maxillary expansion (RME) can be used as an aid for the control of vertical dimension estimation.

Keywords: Orthodontics. Malocclusion. Vertical dimension. Systematic reviews as topic.

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Introduction

Excessive vertical facial height has been referred to by a variety of names, such as hyper-divergency, leptoprosopic pattern, and dolichofacial pattern[1].

The control of vertical dimension (CVD) has to be adequately regulated for antero-posterior correction to be successful. The shared characteristic of severe clockwise rotation, high angle type, hyper-divergency, dolichofacial pattern, adenoid faces, idiopathic long face, full maxillary alveolar hyperplasia, and vertical maxillary excess is excessive vertical growing of the maxilla. Because of this, it is challenging to categorize this vertical maxillary dysplasia using the conventional anteroposterior system. Mandibular incisors are thought to be the main "bite closers", while maxillary molars are the main "bite openers"[1]. More vertical displacement and rotation of the mandible and maxilla are caused by an increase in the vertical dimension of the face. This might result in lengthier treatment times, a compromise in the therapy's objectives, and less than optimal cosmetic results. When a patient has enough growth potential, the goal of therapy should be to avoid front tooth eruption and to limit and constrain maxillary decline. Orthognathic surgery combined with orthodontics may be the only practical therapy when the degree of vertical deformity is so high that growing modification or concealment cannot provide a satisfactory repair[1].

One popular orthodontics technique that is recommended for the treatment of maxillary transverse deficit is rapid maxillary expansion (RME). In developing individuals with immature skeletal development, orthopaedic expansion occurs when the force exerted on the maxilla and teeth is greater than what is necessary for tooth movement[2]. The force imparted results in the periodontal ligament being compressed, the alveolar processes being bent, the midpalatal suture gradually broadening and opening, and dental tipping[3,4].

Even though maxillary transverse deficiency can be corrected with RME, a safe and dependable orthodontics procedure, some studies[5-11] have concentrated on the unintended effects of strong forces on sutures, periodontal alveolar bone, and dental structures, which are referred to as "adverse effects" (AEs). Furthermore, according to some authors[12,13] using traditional appliances in conjunction with RME encourages the maxilla's anterior and inferior displacement, which results in the mandible's posterior-inferior rotation.

In modern treatment planning, RME has always been advantageous when used for orthodontics reasons. This might be another significant point of contention if it is connected to the CVD during orthodontic treatment. Changes in vertical dimension throughout growth have been proposed to have an impact on the mandible's antero-posterior position as well as the creation of permanent occlusion[14].

For many years, it has been recommended to remove posterior teeth to manage the control of vertical dimension, particularly in individuals with long faces[15]. It has been suggested that eliminating permanent teeth might diminish the vertical dimension of the face or fix an open bite by causing the posterior teeth to migrate forward and cause the jaw to rotate counterclockwise a process known as the wedge effect[16-18]. Several publications claim that extractions reduce the vertical dimension in patients who have skeletal open bites as well as hyper-divergent individuals[19,20]. However, other research did not find any evidence of a discernible impact of extraction treatment on the vertical dimension of the face[21,22].

A sizable portion (22%) of orthodontics patients treated globally are hyperdivergent individuals[23]. Therefore, a typical choice made in every practice is whether to use an extraction or non-extraction treatment regimen based on effects in the vertical dimension. However, the inconsistent results of earlier research prevent evidence-based decision-making, which results in drastically disparate patient strategies used by different doctors.

To address the following goal regarding the regulation of control of vertical dimension (CVD) in growing individuals, the current systematic review was conducted. Is CVD always beneficial in Rapid Maxillary Expansion (RME) the mandibular position is altered by these orthopaedic and orthodontic side effects on the maxilla.

Materials and Methods

The Preferred Reporting Items for Systematic Reviews (PRISMA) were taken into consideration and the standards for systematic reviewing technique were followed in the execution of this study (Figure 1)[24]. The International Prospective Register of Systematic Reviews (PROSPERO; registration number CRD42023411959) has this review listed.

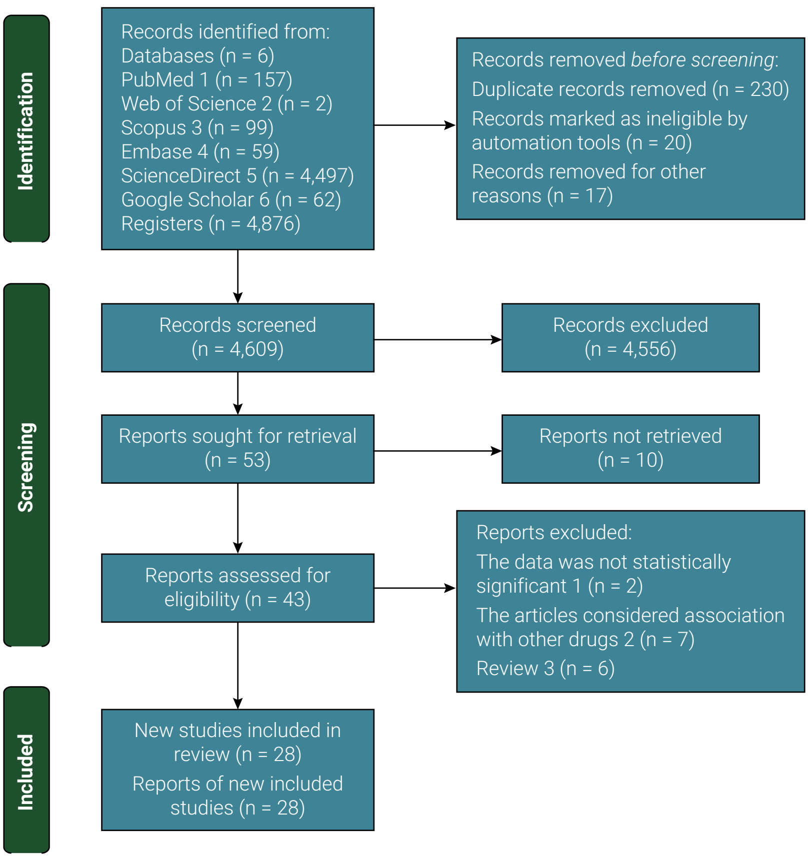

Figure 1. PRISMA chart flow.

Search strategy for identification of studies

We searched full-text publications, were of 6 electronic databases in PubMed, Web of Science, Scopus, Embase, Google Scholar, and ScienceDirect databases in English language, we searched PubMed, Scopus and Web of Science (last search date April 26, 2023), Embase (last search date April 28, 2023), Google Scholar (last search date January 25, 2024) and ScienceDirect (last search date January 30, 2024) for relevant studies. See here the full search strategy. The search strategy for the PubMed database was as follows: ((("Occlusal vertical dimension" OR OVD OR VDO OR "Vertical Dimension"[Mesh]) AND (("Orthodontics/classification"[Mesh] OR "Orthodontics/instrumentation"[Mesh] OR "Orthodontics/methods"[Mesh]) OR "dental orthodontics" OR Orthodontics)) AND (Orthopaedic OR orthopedic OR Orthopedical OR "orthopedic treatment" OR "dental orthopedic" OR "dental orthopaedics" OR ("Orthopedics/classification"[Mesh] OR "Orthopedics/methods"[Mesh]))) AND (Orthopaedic OR orthopedic OR Orthopedical OR "orthopedic treatment" OR "dental orthopedic" OR "dental orthopaedics" OR ("Orthopedics/classification"[Mesh] OR "Orthopedics/methods"[Mesh])). The electronic bibliographic databases Google Scholar, Scopus, Embase, Web of Science, and ScienceDirect have all embraced this tactic. Quotation marks and plural versions of the search words were used, depending on the database.

Eligibility Criteria

From 1970 to 2024, we examined cross-sectional research, case-control studies, case studies, systematic reviews, and meta-analyses. The analysis did not include duplicate articles.

Review Strategy

The text was used to display the examined data. Additionally, Table 1 summarizes the results on control of vertical dimension (CVD), rapid maxillary expansion (RME), orthopaedic and orthodontics, and whether or not there is a correlation between orthopaedic therapy and control of vertical dimension.

Table 1. Systematic review results.

Study	Effect on vertical dimension (mean ± SD)	Effect on alveolar structures	Effect on dental tapping
Chung and Font.[10]	SN-MP = 1.7° ± 1.2° N-Me = 3.4 ± 1.6 mm PP-MP = 1.6° ± 1.7°		
Lagravere et al.[11]	Infra Or-Me: End of expansion = 1.5 ± 4.2 mm After 6 months = 1.2 ± 1.5 mm After 12 months = 1.7 ± 1.9 mm		End expansion: 16 = 9.2° ± 5.1° 26 = 9.2° ± 4.9° After 6 months: 16 = 6.4° ± 3.0° 26 = 7.0° ± 5.2° After 12 months: 16 = 4.7° ± 4.3° 26 = 4.8° ± 3.4°

Continue

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Basciftci and Karaman[12]	SN-MP = 1.8° ± 1.4° PP-MP = 1.3° ± 1.4° N-ANS = 1.3 ± 2.4 mm ANS-Me = 2.6 ± 2.3 mm	Bending = 5.1° ± 3.8°	
Rossi et al.[13]	N-ANS = 1.6 ± 1.9 mm S-Go = 1.5 ± 2.4 mm ANS-Me = 0.6 ± 1.4 mm N-Me = 2.7 ± 2.2 mm		
Cozza et al.[25]	SN-PP = 1.7° ± 2.6° N-Me = 1 ± 2.2 mm SN-ANS = 1.6 ± 2.3 mm		
Akkaya et al.[26]	SN/ANS-PNS (°) = -0.40 ± 0.09 ANS-PNS/MP (°) = -0.22 ± 0.30		
Reed et al.[27]	Bonded RME: GoGn-SN = 0.6° ± 1.6° Anterior lower facial height = 2.7 ± 3.5 mm Anterior total facial height = 4.5 ± 3.5 mm Bonded RME: Anterior lower facial height = 2.2 ± 2.4 mm Anterior total facial height = 4.3 ± 2.4 mm		
Asanza et al.[28]	Bonded RME: SN-PSN = 1.9 mm SN-ANS = 1.5 mm SN-MP = 2.2° Bonded: SN-PNS = 0.3 mm SN-ANS = 1.5 mm SN-MP = 1.5°		Bonded RME: 16 = 4.0° 26 = 3.7° Bonded RME: 16 = 2.6° 26 = 4.2°
Sandikcioglu and Hazar[29]	SN-GoGn = 1.5° ± 1.3° SN-ANS = 1.5 ± 1.4 N-Gn = 3.8 ± 1.4 mm ANS-Gn = 2.6 ± 1.9 mm		
Sarver and Johnston[30]	Bonded RME: SN-PNS = 0.9 ± 0.1 mm Bonded RME: SN-PNS = 0.4 ± 0.2 mm		
Westwood et al.[31]	A Bonded RME: N-ANS = 2.2± 1.2 mm ANS-Me = 2.4 ± 1.4 mm B Bonded RME: N-ANS = 2.1± 1.6 mm ANS-Me = 1.5 ± 1.6 mm		
Ulger et al.[32]	Group C ANS-Me = 0.50 ± 1.00 mm N-Me = 3.00 ± 0.95 mm ANS-Me/N-me (%) = -0.56 ± 0.57 Group CU ANS-Me = 1.3 ± 1.1 mm N-Me = 3.17 ± 1.64 mm ANS-Me/N-me (%) = -0.46 ± 0.61		
Cook et al.[33]	N-Me 2.68 ± 3.13 mm ANS-Me = - 0.16 ± 2.53 mm		

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Continuation

Lione et al.[34]	A Bonded RME: SN to mandibular plane (deg) = −0.6 ± 0.8 mm lower anterior facial height (ANS-Me) = −0.3 ± 0.8 B Bonded RME: SN to mandibular plane (deg) (Me-Go) = 0.5 ± 0.6 mm lower anterior facial height (ANS-Me) = 0.5 ± 0.7
Nienkemper et al.[35]	N-Me = 111.0 ± 6.7 mm ANS-Me = -64.1 ± 5.8 mm
Nartallo-Turley and Turley[36]	Palatal plane ANS/PNS-SN = -1.9 ± 1.8 mm GO-GN-SN = 1.6 ± 1.5 Mandibular plane Go/Gn-SN = 1.7 ± 2.8
Gkantidis et al.[21]	Group A SN-GoGn = 38.4° ± 3.8° ANS-Me (mm)= 264.7 ± 4.9 Group B SN-GoGn = 39.1° ± 3.8° ANS-Me (mm) = 64.0 ± 4.9
Kirschneck et al.[37]	SN-GoGn (°), (mean 6 SD) = 2.8 (2.3-4.8)
Kocadereli[38]	SN-GoGn (°), FMA (°), N-Me (mm), ANS-Me (mm) = NA
Kumari and Fida[39]	FMA (°), N-Me (mm), N-ANS/ ANS-Me (ratio) = NA
Luppanapornlap and Johnston[40]	FMA (°), N-Me (mm), ANS-Me (mm) = NA
Porto et al.[41]	N-GoGn (°), FMA (°) N-S-Gn (°) 2.5 ± 0.7 y 2.2 ± 0.4
Sivakumar and Valiathan[42]	GoMe-FH (°), N-Me (mm), NS-Me (mm) 1.5 y 2.9
Staggers[43]	MP-HP (°), N-Me (mm), -ANS/ANS-Me (ratio) = NA
Paquette et al.[44]	FMA (°), N-Me (mm) ANS-Me (mm) 1.8 y 1.6
Sar et al.[45]	MP + FM (1): N-Me (mm) = 2.73 ± 2.76 ANS-Me (mm) = 2.10 ± 1.79 N-ANS (mm) = 0.56 ± 2.29 FM (2): N-Me (mm) = 4.63 ± 1.96 ANS-Me (mm) = 3.96± 1.74 N-ANS (mm) = 0.70 ± 1.29
Lione et al.[46]	N-Me mm = 4.4 ± 6.1 N-ANS mm = 0.8 ± 5.3
Sambataro et al.[47]	T1 N-ANS/ANS-Me (ratio) = 0.9 ± 0.1 T2 N-ANS/ANS-Me (ratio) = 1.0± 0.1

Article Screening and Selection

The reference management program Rayyan was used to import all of the entries found via the electronic database search (Intelligent Systematic Review). Following the elimination of duplicates, two independent reviewers (RMLT and WRR) evaluated titles, abstracts, and full-text articles to determine their eligibility based on the following inclusion criteria: publications written in English, released between 1970 and January 2024, and about human studies; additionally, studies that targeted particular populations, such as patients with cancer or other serious illnesses, were disqualified. Articles examining the relationships between orthopaedic treatment groups and Control of Vertical Dimension in orthodontics, or the adherence to a particular CVD without examining the relationship with RME, were also disregarded. The following conditions were published as exclusion criteria: patients in need of functional appliance therapy; individuals with hypodontia; craniofacial syndromes or clefts; prior orthodontic treatment or extractions, including upper third molar extractions; and those with prior upper molar prosthodontic therapies. The loss of deciduous teeth during treatment and the use of any additional appliances, including lip bumpers, mandibular lingual arches, or fixed or functional appliances, either before or during the observation period, were other factors for exclusion. Article exclusion criteria were recorded. Disagreements between the two reviewers were addressed with a third reviewer (TJRB) throughout the article screening process. If further information was needed, the review team got in touch with the authors.

Data Synthesis

From 26 April 2023 to 30 January 2024, a double-independent peer review process was used to perform the search. Using keywords, 4876 articles were located. Only 28 articles, out of the 43 that we examined after elimination, matched the search. The data in these articles were not statistically significant; the CVD data did not match the international nomenclature databases; the articles did not indicate any associations with specific control of the vertical dimension (CVD)/rapid maxillary expansion (RME); and the articles examined associations with other manifestations of these orthopaedic and orthodontics side effects on the maxilla that result in a change in mandibular position were excluded.

Results

A search using the U.S. National Library of Medicine MeSH (medical subject headings) terms yielded the following results: PubMed yielded 157 publications; Embase, 59 publications; Web of Science, 2 publications; ScienceDirect, 4497 publications; and Google Scholar, 62 publications; Scopus, 99 publications. There was overlap among the databases. Application of the inclusion and exclusion criteria and follow-up on the referred studies identified 28 relevant publications (Figure 1)[10-13,21,25-47].

All selected articles were based on human studies. Of the 43 articles, 28 were considered to be of high methodologic quality, and the remaining 28 articles were rated as medium quality (Table 1). The primary flaws in the research's quality were the small size of the study sample subgroups, the lack of measurement blinding, and the lack of a prior power estimate.

The findings of the studies using comparable maxillary expansion techniques have a considerable degree of heterogeneity (>85%). For this reason, a meta-analysis was not carried out. Eighteen studies[10,25-27,29-32,36-44] were retrospective, four studies[12,13,28,45] was prospective, and six studies[11,33-35,46,47] was prospective and randomized. Eleven studies[10-13,25-30,34] analyzed the long-term effects of RME. Fifteen studies[21,31-33,35-45] specified that the subjects of the study groups were selected consecutively. The mean age at the start of orthopedic expansion in the evaluated samples ranged from 7 to 18 years.

Effects on the vertical dimension on the growing subjects

According to Kumari and Fida[39], in skeletal Class I hyper-divergent individuals, there is a statistically significant increase in N-Me distance (4 mm) in the no extraction compared with extraction therapy; the FMA angle and N-ANS/ANS-Me ratio did not change.

Similar findings were found by Paquette et al.,[44] who found that in dental Class II, 1 normal-divergent patient, non-extraction therapy resulted in a statistically significant but clinically dubious reduction in FMA angle (2.3°); no differences were seen in N-Me or ANS-Me distance.

In dental Class II, 1 hyper-divergent individual, Porto et al.,[41] report a statistically significant, if clinically dubious, increase in SN-GoGn angle (1.7°) in non-extraction compared with extraction therapy; no change in FMA angle was seen.

Between 1.6 and 4.3 mm was the range of the midpalatal suture opening in the front area and between 1.2 and 4.4 mm in the posterior region. RME caused the maxilla to shift somewhat inferiorly after the active phase (SN-PNS +0.9 mm; SN-ANS +1.6 mm), the anchored teeth to tip more from 3.4° to 9.2°, and the alveolar bone to bend from 5.1° to 11.3°. Over an extended period, RME did not alter face development patterns, nor did it show any appreciable alterations to dentoalveolar structures. Two were medium-high quality, eight were medium quality, and twenty were poor quality out of the thirty studies[10-13,25,26].

Regarding the T2–T1 alterations, the research conducted by Lione et al.,[34] did not find any statistically significant variations between the untreated CG and the maxilla and mandible's sagittal positions after the RME treatment. The TG1 group had discernible noteworthy alterations, characterized by increased reductions in facial divergency (TG1 against TG2, − 1.1°; TG1 versus CG, − 1.5°) and gonial angle (TG1 versus TG2, − 1.3°; TG1 versus CG, − 1.5°). Compared to the untreated controls, the RME treatment had no discernible effect on dental measures or the molar relationship.

In recent research, it was shown that the hybrid hyrax-FM combination was beneficial for short-term orthopedic therapy in developing Class III patients. Positive skeletal alterations were seen in the mandible and maxilla. There was no evidence of dentoalveolar compensations[35]. Skeletal sagittal parameters showed a significant improvement in the treatment group compared to the controls: SNA: 2.4°, SNB: −1.7°, Co-Gn: −2.3 mm, Wit's appraisal: 4.5 mm. In terms of vertical shifts, a slight significant reduction in the Co-Go-Me angle and a little nonsignificant rise in FMA indicated that vertical growth had been maintained[35].

Vertical Components

Class II malocclusion is often considered a sagittal problem; however, one must also consider the vertical dimension of the patient. According to Schudy, variations in facial height may either highlight or conceal the clinical appearance of malocclusion[14,48].

A. **Decreased vertical dimension.** The mandible rotates upward and forward due to a reduction in vertical dimension, as is widely recognized in prosthodontics and surgical maxillary impaction. A mandible that is fundamentally tiny about the mid-face might be hidden by a short lower anterior facial height, which is also the case with Class II orthodontic patients. These individuals usually have either flared or retruded upper incisors, a deep overbite with a prominent chin point, and a low mandibular plane angle. Dentoalveolar retrusion of the mandible also occurs[14,48].

B. **Increased vertical dimension.** Patients with a high lower anterior facial height often present with a retruded mandible (and sometimes the maxilla as well), a poorly defined chin point with an overactive mentalis muscle (commonly referred to as a "golf-ball" chin), and a tendency toward an anterior open bite. A "dorsal hump" a bulge on the nasal contour is often seen clinically in people with both maxillary and mandibular skeletal retrusion and a Class II malocclusion[14,48].

The evaluation's findings from the previous research show that two vertical dimension measurements are looked at to determine how often these issues occur in the Class II mixed dentition group[49]. Calculating the mandibular plane angle concerning the Frankfort horizontal reveals that around 40% of the sample has a neutral vertical dimension. A mandibular plane angle of more than 31.5 ° is seen in 17.5% of the sample, indicating excessive vertical development. Facial height loss associated with Class II division 2 malocclusion is often seen in the 10% of the sample who had a short lower anterior facial height. An evaluation of lower anterior facial height a measurement made from the anterior nasal spine to the chin showed that more than half of the individuals had normal face heights. About 35% of the group had an abnormally low anterior facial height[49].

Vertical Dimension

Because researchers have not all agreed on how cervical headgear treatment affects the vertical dimension, there is no consensus on how this sort of therapy affects the different vertical facial metrics[47].

The majority of the adjustments to the vertical dimension have been included in the previously stated sagittal correction discussion. Therefore, what follows will merely be a synopsis of the vertical alterations brought about by FR therapy. Data from the McNamara et al. u6 two-year clinical study show that mandibular length increased above control values by 60% in the younger age group and 82% in the older age group. However, these gains in mandibular length are not always accompanied by an equal advancement of the chin point. The degree of increased lower anterior facial height created following therapy is negatively correlated with changes in the chin's horizontal position. Increased mandibular length may be used to move the chin as far anteriorly as possible without also increasing lower anterior facial height. On the other hand, a marked rise in lower face height may mask a considerable increase in mandibular length. It has been shown that FR therapy causes these increases[50].

A. **Mandibular plane angle and lower anterior facial height.** By altering the variables influencing the soft tissue profile, orthodontic treatment may contribute to an increase in the attractiveness of the face. Recent research examined the effects of lower anterior facial heights (both at rest and while grinning) and varying maxillary incisal inclinations on the facial attractiveness of Asian woman[51] and male[52].

B. **Occlusal plane angle.** Researchers disagree on how extraoral traction influences the orientation of the occlusal plane for the cranial base. The anatomic occlusal plane often closes with aging. There has reportedly been a rise in the occlusal plane's angle concerning the cranial base while the angle stays mostly constant during therapy. saw that the anterior portion of the palatal plane was somewhat tipped downward. Along with treatment, the functional occlusal plane is also somewhat closed[53].

C. **Palatal plane angle.** Due to the uneven anterior tipping descent of the palatal plane, the anterior nasal spine tips more inferiorly than the posterior nasal spine. However, it was also seen that the palatal plane's angulation remained unaltered[54,55].

Discussion

In orthodontics, control of vertical dimension has always been crucial. An essential feature of the human face, the vertical dimension often influences treatment plans. For instance, treating physicians may use invasive techniques like teeth extractions or high-pull headgear because they are worried about decreasing, or at least not increasing, the vertical dimension of the face in hyperdivergent patients. For individuals with a small lower anterior face height, the reverse is true. Thus, choosing whether or not to remove teeth is a crucial treatment planning choice that has garnered a lot of attention in the literature when taking the vertical dimension into account. This is a very contentious topic since some research suggests that excision of the posterior teeth might either better manage the vertical dimension in hyper-divergent individuals or lessen it altogether[56]. This comprehensive study, however, unequivocally shows that there is no evidence at all to support this clinical notion. While several of the studies in our evaluation stated in their conclusions sections that the choice of extractions had an impact on the vertical dimension, their data[42,56]. did not support this claim. This data shows how ingrained this idea is in the views of therapists.

We tested the effect of only six studies[11,33-35,46,47] was randomized out of the combined retrospective and prospective studies included in this systematic review. The results of these studies should be regarded cautiously since the technique used was often of poor to medium quality (Table 1). The majority of studies were severely limited by the absence of a sufficient untreated control group.

Regardless of the kind of palatal expander used, the analysis of the 28 publications[10-13,21,25-47] included in this study indicates that CVD is a successful operation that consistently opens the midpalatal suture in developing patients, producing transverse skeletal consequences on the maxilla. The findings demonstrated that when CDV therapy was started before the pubertal peak in skeletal development, it was able to much more favorably induce skeletal alterations in the transverse plane[7,9,57-61]. It may be seen that studies[59,60] with a younger research sample also found a broader opening of the midpalate suture, supporting the idea that treatment timing affects the skeletal alterations that occur after RME therapy. Except for Christie et al.[59], research which discovered a parallel pattern of midpalatal suture opening, all investigations showed that the anterior area had higher quantities of midpalatal suture opening than the posterior region.

The maxilla and posterior teeth of the maxillary system have been shown to migrate lower after RME therapy[2-4,10,12]. Changes in the measures of SN-PNS (+0.9 mm) and SN-ANS (+1.6 mm) show that RME led to a little inferior displacement of the maxilla, as described by numerous of the publications included in this study[10-13,25-30] Several writers[10-13,25-30] noted that the mandible rotates downward and backward due to the maxilla's downward migration and early dental contacts, with a mean increase in the following variables: SN-MP, 1.7°; PP-MP, 1.5°; SN-PP, 1.6°; and SN-GoGn, 1.1°[10-13,25-30]. Less than 2 mm or 2° changed in vertical dimension before and after RME therapy; these changes could not be regarded as clinically significant[25]. The overall anterior facial height (N-Me: 3.2 mm) was the only variable in the short-term assessment to grow more than the others. This might be the temporary outcome of occlusal interferences[10,13,25,27].

There is substantial variability six months after the removal of the RME appliance, despite the maxilla's displacement downward, neither the direction nor the patterns of facial or mandibular development changed, as reported by the two long-term investigations of Rossi et al.[13] and Lagravere et al.[11] These results support the findings of previous research[62,63] that assessed the vertical effects of RME longitudinally as well; however, in those investigations, RME was followed by further orthodontic treatment[62,63]. Furthermore, Lagravere et al.[11] and Cozza et al.[25] found that there were very few changes in vertical dimension when compared to an untreated control group[11,25]. Compared to the banded RME, the bonded RME had reduced inferior PNS movement[27,30,37]. This may be because the interocclusal acrylic violates the freeway space and acts as an intrusive force on the maxilla's basal bone, forcing the elevator musculature to passively expand. The results of the retrieved research suggested a vertical control mechanism that counteracts the adverse events (AEs) associated with other expansion devices through a bonded RME[27,30,37].

Regardless of the kind of expanders, seven papers[4,6,8,11,28,58,59] showed that strong pressures resulted in an increased buccal inclination of attached teeth after the active period. The short-term effects of RME on alveolar structures were also noted by Ciambotti et al.[4] and Kilic et al.[6] They discovered that the alveolar halves spread buccally and carried the teeth with them. Anchored teeth and alveolar bone migrate simultaneously in developing individuals in the same direction and magnitude[4,6]. The bonded RME group's posterior teeth inclination seemed to be more stable for the acrylic covering's activity[6,8]. According to Lagravere et al.[11], expansion relapse caused the dental tipping to look decrease by almost half 12 months after the cessation of active expansion. After a mean of 17.9 months, Kartalian et al.[64] compared measures obtained on cone-beam CT scans between patients receiving RME therapy and controls. The RME group observed that while the dentition's angulation was constant (−0.8°) before and after treatment, the alveolus tipped buccally by 5.6°, most likely due to post-expansion relapse of dental axial angulation[64].

For the patterns of the three-month retention period, expansion groups showed no changes in their periodontal state as compared to the control group, as shown by Greenbaum and Zachrisson[65] using computed tomography axial images, Ballanti et al.[5] found that following a 6-month retention period, orthodontics stresses in prepubertal participants did not affect the alveolar bone palatal and buccal thickness. After the movement of the attached teeth is finished, the alveolar plate needs time to heal, which was determined to be six months.

Most studies in this review assessed because the measures of lower anterior and total anterior face heights are linear, they rely heavily on the development rate of the individual throughout the period under study. A ratio known as ANS-Me, Na-Me, or LAFH: TAFH, was determined to account for this uniqueness and potential secular tendencies. The findings show that the two treatment groups had a lesser rise in LAFH, which led to a smaller change in this ratio when compared to the untreated control. This research demonstrated that the anterior region of the palatal plane (ANS) descended as a result of the CHG. The reduction in the linear measurement from ANS to chin may be ascribed to the orthopedic rotation of the maxillary complex brought on by the cervical headpiece, since the jaw did not rotate open, creating a decline in Menton[33]. It is incorrect to think of the craniofacial complex which includes the masticatory system as a simple articulator since it is quite complex. The creation of the vertical placements of the teeth and the corresponding skeletal patterns is presumably due to variables other than tooth counts, such as neuromuscular balance and function[56].

Limitations

The faulty reporting turned out to be a significant shortcoming of this study. For instance, it was often not possible to find sufficient information on characteristics and variables crucial for evaluating the comparability of research, such as development status, kind of excised teeth, malocclusion pattern, or specific treatment specifics. Moreover, several studies did not adjust the lateral cephalograms' magnification factor while evaluating linear measures, which introduced errors in these variables. Therefore, any quantitative synthesis was impossible due to inadequate reporting as well as the significant methodological, statistical, and clinical heterogeneity between investigations.

Due to the lack of a treated control group in the few controlled trials that examined various extraction patterns in the literature, our review was restricted to CVD therapies. Moreover, every study that was included was retrospective, which presents an intrinsic constraint to our evaluation since biases of all kinds, including selection bias, may occur in retrospective research. The challenge of prospectively gathering these samples, for pragmatic and ethical reasons, maybe the reason for the dearth of prospective or randomized clinical studies.

In conclusion, small sample sizes, bias, confounding factors, a lack of method error analysis, measurement blinding, and inadequate or absent statistical techniques were among the methodological issues that the majority of the research had. The research's quality level was insufficient to allow for the development of any conclusions based on solid data. Regardless of the kind of palatal expander used, RME is a successful operation that may always have transverse skeletal effects on the maxilla by expanding the midpalatal suture in growing patients.

Despite being statistically significant, the control of vertical dimension alterations seen after RME therapy was minimal and most likely temporary. For the correction of a narrow maxilla, the bonded maxillary expansion appliance may be a good choice, independent of the patient's vertical issues or face structure. In the short-term assessment, large pressures moved the alveolar bone and anchored teeth in growing participants simultaneously, with the same magnitude and direction. During the long-term assessment, anchored teeth were shown to straighten. After three months, active root resorption and enhanced filling with cellular cementum were seen, coupled with reversible vascular alterations after RME.

Data availability

Datasets associated with this paper will be provided to the appropriate author upon request.

Conflict of Interest

The authors have no conflict of interest to disclose.

Author Contribution

Roe Mio Lopez Toribio: planned the systematic review, conducted the literature search, selected studies, and extracted data from the primary studies. **Tania Janeth Romero Berrios**: designed the systematic review, conducted the literature search, selected studies, and extracted data from the primary studies. **Wilder Requez Robles**: designed the systematic review, conducted the literature search, selected studies, and extracted data from the primary studies. All authors assisted in resolving issues, wrote the first draft of the manuscript, and contributed to and approved the final manuscript.

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