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Systematic review

Short-term treatment effects produced by the Twin-block appliance: a systematic review and meta-analysis

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Summary

Objective: To evaluate dental, skeletal, and soft tissue effects during Twin-block treatment.
Methods: A systematic search of several electronic databases (Medline, PubMed, Embase, all EBM reviews, and Web of Science) was conducted until July 2013, as well as a limited grey-literature search (Google Scholar). Human cephalometric studies that used a Twin-block appliance in a non-extraction and non-surgical approach were selected. A comparable control group of untreated subjects was required. Two authors independently reviewed and extracted data from the selected studies. Risk of bias was assessed. The type of meta-analysis was selected based on heterogeneity.
Results: Ultimately 10 articles were included. Proclination of lower incisors, retroclination of upper incisors, distal movement of upper molars and/or mesial movement of lower molars, increase in mandibular length, and/or forward movement of the mandible were consistently reported. Clinically significant restraint of maxillary growth was not found. Although the mandibular body length is increased, the facial impact of it is reduced by the simultaneous increment of the face height. Changes of lower face height and occlusal plane inclination varied, suggesting that vertical dimension can be manipulated in patients who would benefit from lower molar extrusion. As for lip position, there is not enough evidence to suggest clear lip position changes.
Conclusions: Changes associated with a Class II correction were identified. Most of the changes individually were of limited clinical significance, but when combined reached clinical importance. No long-term changes were available.

Introduction

Class II functional appliances are indicated in the correction of mandibular deficiencies as they allow mandibular postural changes by holding the mandible forward and/or downward (1). The muscles and soft tissues are stretched with the generated pressure transmitted to the skeletal and dental structures potentially resulting in skeletal growth modification and tooth movement (1).

Both fixed and removable Class II functional appliances are used to improve Class II malocclusions. Since the success with removable appliances largely depends on patient's compliance, using a more tolerable appliance can increase the chances of a favourable outcome. Twin-blocks are upper and lower acrylic bite blocks with occlusal inclined planes that interlock at a 70 degree angle and guide the mandible forward and downward (2). It has been suggested that compared to other functional appliances, success rate with Twin-block is favourable because it is generally better tolerated by patients (3,4) as it is smaller than other functional appliances, has no visible acrylic portion anteriorly, and its interference with speech is minimal (4).

Several studies have evaluated the skeletal and/or dental changes with Twin-block treatment, but to date, only one systematic review (5) of Twin-block's treatment effects has been conducted, which focused exclusively on soft tissue changes. The objective of this study is to systematically evaluate short-term dental, skeletal, and soft tissue effects of treatment with Twin-block appliance in comparison to an untreated sample among individuals with a mild-to-moderate Class II division 1 malocclusion. This information should serve clinicians considering the use of Twin-blocks to better understand the potential treatment effects to be produced.

Materials and methods

Protocol registration

The study protocol was not registered.

Information sources

A systematic computerized search of electronic databases was carried out in Medline, PubMed, Embase, all EBM reviews (Cochrane DSR, ACP Journal Club, DARE, CCTR, CMR, HTA, and NHSEED), and Web of Science until July 2013.

Search strategy

Details of the terms and how they were combined per database can be found in Table 1. No restrictions were applied to the electronic searches. Duplicate results were removed upon identification.

Eligibility criteria

The following criteria were chosen:

- Human studies
- Cephalometric studies
- Having treated with Twin-block appliance with a non-extraction and non-surgical approach to prevent introduction of confounding factors
- Having a control group of untreated cases with a Class II malocclusion because mandibular growth of Class II individuals has been shown to be different from that of Class I cases (6).

Study selection

Titles and abstracts of the results were then scrutinized to identify the articles that met the initial selection criteria. Articles, based on the abstracts/titles, that did not meet the initial selection criteria were removed. Articles that were descriptive, editorial, letter, not investigating cephalometric variables or had not included untreated cases as a control group were also excluded.

Full texts of the articles were collected based on the abstracts/titles that met the initial selection criteria. Full text was also obtained for the abstracts that were either not available or had not clearly elaborated the above-mentioned initial selection criteria.

If there were more than one publication for the same study, the one, which was more detailed, was selected. Methodological quality of the articles was then evaluated in Tables 2 and 3.

A manual search was also conducted by going through the reference lists of the selected articles to ensure that no potentially acceptable articles were missing from the electronic searches.

Data items and collection

Skeletal and dental cephalometric findings including mandibular and maxillary dimensions, mandibular and maxillary antero-posterior positions, sagittal intermaxillary relationship, mesio-distal position of maxillary and mandibular first molars, inclination of maxillary and mandibular incisors, and vertical dimensions were collected from the articles. Two reviewers conducted both selection processes independently. Discrepancies between the two were resolved through discussion until a consensus was reached for the finally selected articles.

Risk of bias in individual studies

Risk of bias was assessed through the evaluation of methodological quality study characteristics (Table 2) (15). It must be noted that the employed methodological scoring system was modified from the original and is not validated. This type of quality assessment can be considered subjective. Factors such as intra-rater reliability, inter-rater reliability, and blinding of examiner and/or statistician were considered. If both inter-rater and intra-rater reliability were tested and randomization was carried out, the study was rated as low risk for bias. If inter-rater reliability was not assessed and randomization was not performed either, the study was rated as high risk for bias. All other studies were categorized as medium risk for bias (Table 3).

Summary measures

Basic study characteristics can be found in Table 4. Means and standard deviations were obtained for the cephalometric variables listed above. Due to the fact that the included studies reported values from different treatment time lengths, it was decided to annualize the reported changes to be able to properly compare the change rates between studies.

Table 1. Search dates, search strategies, and number of results for each database.

Database	Search strategy
Medline: 1948 to present	(twin block OR twin-block OR twinblock) AND [(treatment outcome OR treatment effect$) OR (skeletal effect$ OR skeletal change) OR (dental effect$ OR dental change) OR (facial change or profile change or soft-tissue change)]
All EBM reviews—Cochrane DSR, ACP Journal Club, DARE, CCTR, CMR, HTA, and NHSEED	Same as Medline
PubMed: 1950 to present	Same as Medline
Web of Science: 1899 to present	((TS=(twin block OR twin-block OR twinblock) AND TS= (orthodont*)) AND ((TS=(treatment outcome) OR (TS=(treatment effect*) OR (TS=(skeletal change) OR (TS=(skeletal effect*) OR (TS=(dental change) OR (TS=(dental effect*)OR (TS=(facial change OR profile change OR soft-tissue change))); DocType=(Article); Language=All languages; Database(s)=SCI-EXPANDED
Embase: 1980 to present	Same as Medline

Table 2. Methodological score used in the review.

I. Study design (6√)
  A. Objective—objective clearly formulated (√)
  B. Sample size—considered adequate and estimated before collection of data (√)
  C. Baseline characteristics—similar baseline characteristics (√)
  D. Co-interventions (√)
  E. Randomization—random sampling (√); random allocation of treatment (√)
II. Study measurements (5√)
  F. Measurement method—appropriate to the objective (√)
  G. Blind measurement—blinding (examiner √, statistician √)
  H. Reliability—described (√), adequate level of agreement (√)
III. Statistical analysis (5√)
  I. Statistical analysis—appropriate for data (√); combined subgroup analysis (√)
  J. Confounders (co-interventions)—confounders included in analysis (√)
  K. Statistical significance level—*P* value stated (√); confidence intervals (√)
IV. Other (1√)
  L. Clinical significance (√)
Maximum number of √s = 17

√ = met; × = not met; / = partially met.

Risk of bias between studies

Based on the heterogeneity (as determined by I^2) between the selected studies, the type of meta-analysis (fixed- or random-effect models) was selected. Publication bias, sensitivity analysis, and selective reporting within studies were not assessed due to the limited number of studies included per analysed variable.

Results

Search process and study selection

Finally, 10 articles were included for analysis. Details of the study selection process can be found in Supplementary Appendix 1 and Figure—PRISMA Flow Diagram.

Study characteristics and risk of bias

A summary of the methodological scores of the selected articles is illustrated in Table 3. Six of the selected articles were prospective controlled clinical trials (9–14), while the remaining four were retrospective controlled clinical studies (3,4,7,8). Overall, all studies, except for one study (3), examined and reported both inter- and intra-rater reliability. This study (3), however, only reported inter-rater reliability. On the other hand, blinding was done for neither the examiner nor the statistician in any of the studies except for the three studies (8,11,14), which had the examiners blinded. Based on randomization, blinding, and reliability testing, studies were classified as having a low, medium, or high risk of bias.

The age of the samples at baseline varied in the studies: two studies (4,11) investigated patients at a younger age, whereas six studies (7–10,13,14) investigated older patients. Subjects of the remaining studies (3,12) were at neither of the extreme ends of the range.

One study (14) selected patients who were exhibiting maximum pubertal growth, whereas only one study (7) included two distinct age groups, one with Cervical Vertebrae Maturation (CVM) stages 1–3 (9 years) and one with CVM stages 4–6 (12 years 11 months), with the objective to determine the optimum timing for Twin-block

Table 3. Methodological scores for the selected articles.

						Randomization			Blinding		Reliability testing								
		Objective	Sample size	Baseline	No co-interventions	Random sampling	Random allocation	Measurement method	Examiner	Statistician	Intra-rater	Inter-rater	Statistical analysis	Confounders included in analysis	*P* value	Confidence interval	Clinical significance	Total *score (out of 17)	Risk of bias
1	Baccetti *et al.* (7)	√	/	×	√	×	×	√	×	×	√	√	/	×	√	√	√	9	M
2	Illing *et al.* (8)	√	/	√	√	×	√	√	√	×	√	√	√	√	√	√	√	14	L
3	Jena *et al.* (9)	√	/	√	√	×	×	√	×	×	√	√	√	√	√	√	√	12	M
4	Lund and Sandler (10)	√	√	√	√	×	×	√	×	×	√	√	√	√	√	√	√	12	M
5	Mills and McCulloch (4)	√	√	×	√	×	×	√	×	×	√	√	√	×	√	√	√	10	M
6	O'Brien *et al.* (11)	√	√	√	√	×	√	√	√	×	√	√	√	√	√	√	√	14	L
7	Sidlauskas (12)	√	√	√	√	×	×	√	×	×	√	√	/	√	√	√	√	12	M
8	Toth and McNamara (3)	√	√	×	√	×	×	√	×	×	√	×	√	×	√	√	√	9	H
9	Morris *et al.* (13)	√	/	√	√	×	√	√	√	×	√	√	√	√	√	√	√	14	L
10	Varlik *et al.* (14)	√	√	√	√	×	√	√	×	×	√	√	√	√	√	√	√	13	L

√, met; /, partially met; ×, not met; H, high; M, medium; L, low.

Table 4. Summary of selected articles.

	Study type	Sample size		Mean age of combined groups at T1 (years)	Treatment duration (months)
		Twin-block	Control		
Baccetti *et al.* (7)	Retrospective	21 (early group) and 15 (late group)	16 (early group) and 14 (late group)	9 (early group) and 12.9 (late group)	16 (early group) and 15 (late group)
Illing *et al.* (8)	Prospective	16	20	11.2	9
Jena *et al.* (9)	Prospective	25	10	11.4	12.78
Lund and Sandler (10)	Prospective	36	27	12.4	14.4
Mills and McCulloch (4)	Retrospective	28	28	9.1	14
O'Brien *et al.* (11)	Prospective	89	85	9.7	15
Sidlauskas (12)	Retrospective	34	34	10.2	12
Toth and McNamara (3)	Retrospective	40	40	10.4	16
Morris *et al.* (13)	Prospective	16	20	11.2	9
Varlik *et al.* (14)	Prospective	25	25	11.9	8

treatment. They found that treatment in the older group resulted in more orthopaedic changes and larger increases in mandibular length; therefore, they concluded that the optimum timing for treatment with Twin-block is either during or slightly after growth spurt, which usually coincides with late mixed or early permanent dentition stage.

All studies had combined samples of males and females, except for one (9), which only enrolled females in the trial.

Inclusion criteria for almost all the studies included having a Class II molar relationship; the severity of the Class II varied from half cusp to full cusp. Some of the studies limited their samples to Class II division 1 malocclusion. Some studies defined Class II malocclusion based on criteria for overjet (OJ) and/or angle between cephalometric points A, N and B (ANB). Most studies required an OJ of 6 or larger, although there was a study (12) in which OJ was equal to or larger than 5. As for ANB angle, in all studies, this angle was at least equal to or larger than 4 degrees. Only one study (14) defined the mandibular plane angle and included samples with the 'optimal (32 ± 2 degree)' angle.

Treatment duration with Twin-block in the reviewed articles had a wide spectrum ranging from 8 to 16 months. For this reason, annualized rates were calculated.

Summary of skeletal, dental, and soft tissues changes

A summary of the skeletal, dental, and soft tissue changes can be found in Supplementary Appendix 2.

Description of the meta-analysis results can also be found in Supplementary Appendix 2 and in Figures 1–6.

Discussion

Baccetti *et al.* (7) detected that skeletal changes were predominant over the dental changes, regardless of timing of treatment and that increases of both mandibular length and height were larger in the older treatment group who were treated during pubertal growth spurt. They also found that the main orthopaedic effect occurred in the mandible, with no changes in sagittal position of maxilla and no changes in vertical facial relationships. Mills and McCulloch (16) attributed most of the OJ reduction to the mandibular skeletal changes. Lund and Sandler (10) also found the mandibular changes (increase of angle between cephalometric points S, N and B [SNB]) to be the most significant change with Twin-block appliance, with no maxillary skeletal changes. However, unlike Baccetti *et al.* (7) and Mills and McCulloch (16), they found the dentoalveolar effects to be predominant over the skeletal effects; in fact, they attributed most of the OJ reduction to the dentoalveolar changes. The larger increases in Baccetti's late group could be due to the fact that, unlike other studies, they selected their subjects based on skeletal maturation staging. Furthermore, since Lund and Sandler (10) used the distance between Ar and Pog to measure mandibular length, it is unclear if

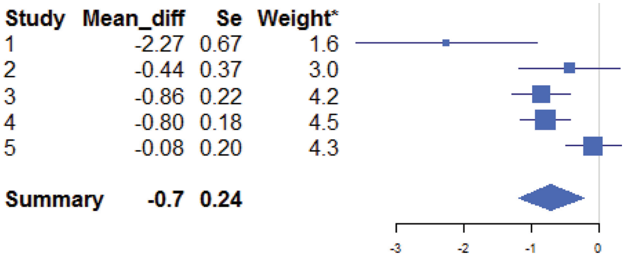

Figure 1. Forest plot in the random effects meta-analysis for angle between cephalometric points S, N and A. (1) Illing *et al.* (8), (2) Lund and Sandler (10), (3) Mills and McCulloch (4), (4) Sidlauskas (12), and (5) Toth and McNamara (3).

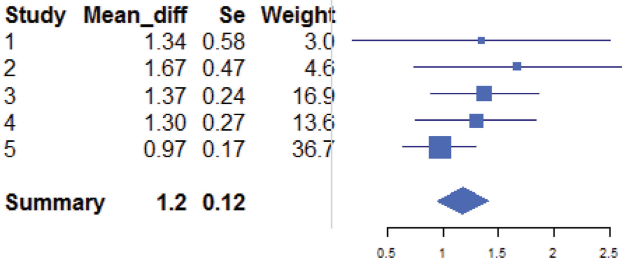

Figure 2. Forest plot in the random effects meta-analysis for angle between cephalometric points S, N and B. (1) Illing *et al.* (8), (2) Lund and Sandler (10), (3) Mills and McCulloch (4), (4) Sidlauskas (12), and (5) Toth and McNamara (3).

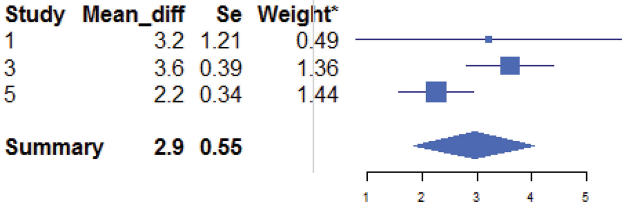

Figure 3. Forest plot in the random effects meta-analysis for distance Co-Gn. (1) Illing *et al.* (8), (2) Mills and McCulloch (4), and (3) Toth and McNamara (3).

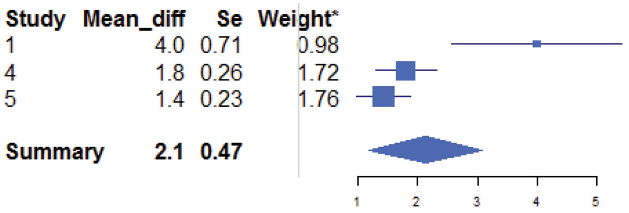

Figure 4. Forest plot in the random effects meta-analysis for lower anterior facial height. (1) Illing *et al.* (8), (4) Sidlauskas (12), and (5) Toth and McNamara (3).

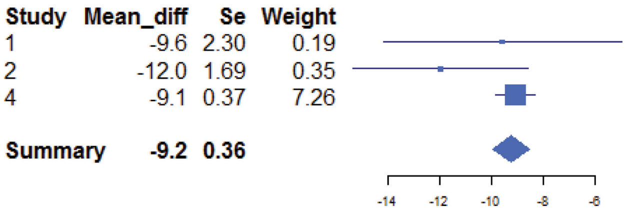

Figure 5. Forest plot in the random effects meta-analysis for angle between U1 and palatal plane. (1) Illing *et al.* (8), (2) Lund and Sandler (10), and (4) Sidlauskas (12).

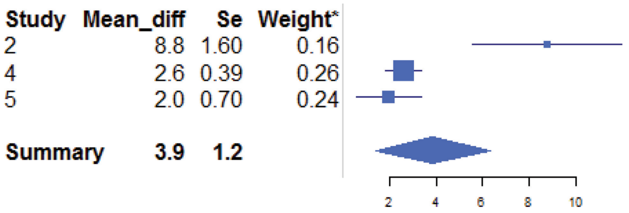

Figure 6. Forest plot in the random effects meta-analysis for angle between L1 and mandibular plane. (2) Lund and Sandler (10), (4) Sidlauskas (12), and (5) Toth and McNamara (3).

the improvement of sagittal relationship of the mandible was due to an actual increase in size or its anterior repositioning. Sidlauskas (12) and Jena *et al.* (9) both attributed more than half of the OJ reduction to skeletal changes. Jena *et al.* (9) also attributed over 70 per cent of the molar correction to the skeletal changes.

On the other hand, the study by O'Brien *et al.* (11) was one of the few studies that did not find significant skeletal changes; they only observed 1 mm mandibular growth with Twin-block and concluded that 73 per cent of the OJ reduction and 59 per cent of the molar correction was due to the dentoalveolar changes. As Jena *et al.* (9) have suggested, the larger skeletal changes that they found compared to O'Brien *et al.* (11) could be due to the difference in the timing of the treatment, as Jena's samples were treated at the peak of their pubertal growth spurt. On the other hand, O'Brien *et al.* (11) argues that most of the studies that have reported significant skeletal improvements were retrospective and therefore exposed to selection bias, resulting in overestimated treatment effects.

Although most studies, except for O'Brien *et al.*'s study (11), found statistically significant increases in angle between cephalometric points S, N and B (SNB), some of these changes, as Sidlauskas (12) points out in regards to his own finding (1.3 degree/year), were not large enough to be considered clinically significant.

As for vertical changes, the mandibular plane angle in studies of Lund and Sandler (10) and Mills and McCulloch (16) did not change with treatment as both anterior and posterior face heights increased with treatment. Toth and McNamara's (3) sample were treated using different approaches with regards to face height: for some, the acrylic on the posterior bite blocks was trimmed to allow for lower molar extrusion and correcting the deep curve of spee, whereas for some, the bite blocks were left intact to provide vertical control. Illing *et al.* (8) too treated their cases based on individual considerations for vertical control as they added occlusal rests to prevent eruption of molars in high angle cases. Therefore, Illing's findings of increase of lower face height and Toth and McNamara's results in terms of vertical control should be both interpreted with caution. Although Sidlausaks (12) found statistically significant increases in lower face height, they concluded that the increase (1.8 mm/year) was clinically negligible. More importantly, they point out that since the lower anterior facial height to total anterior facial height ratio did not change, the proportionality of upper and lower anterior face height was not affected. Finally, Lund and Sandler (10) found that Twin-block did not restrict the upper molar eruption; however, as they suggested, their finding might have been due to merely distal tipping of upper molar (and subsequent extrusion of the mesial cusp), rather than a pure extrusion.

Not surprisingly, findings about maxillary skeletal effects were controversial. Although most studies (including Lund's) did not find a 'headgear effect' with Twin-block, Lund and Sandler (10) hypothesized that the retroclination of the upper incisors and labial tipping of their roots could result in remodelling of the A point to a more anterior position. This potential anterior remodelling could therefore mask any maxillary restraint effects that may have occurred. On the other hand, Mills and McCulloch (4) and Sidlauskas (12) both found statistically significant headgear effect based on reduction of angle between cephalometric points S, N and A (SNA) (1 and 0.8 degree, respectively) and Sidlauskas (12) and O'Brien *et al.* (11) both found statistically significant changes in maxillary base length (0.7 and 0.8 mm, respectively); however, these changes were too small to be considered clinically significant.

As for changes of incisors, most studies found retroclination/retrusion of upper incisors regardless of presence or absence of a labial bow. According to Jena *et al.* (9), the headgear effect of the labial bow in addition to its contact with upper incisors during sleep could be a contributing factor to maxillary incisor retroclination. On the other hand, Toth and McNamara (3) suggested that the retroclination/retrusion could be due to the pressure of upper lip musculature during functional treatment, which could explain the retroclination in the absence of a labial bow in studies of Baccetti *et al.* (7), Mills and McCulloch (4), Illing *et al.* (8), Sidlauskas (12), and Toth and McNamara (3). Overall, all studies except for Baccetti *et al.* (7) found retroclination/retrusion of upper incisors with more severe changes in studies that had used an upper labial bow (9–11).

Also, all studies found proclination/protrusion of lower incisors with Twin-block treatment. This occurred even in studies where either a lower labial bow (4) or an acrylic extension covering edges of lower incisors (12) was used. As Jena *et al.* (9) pointed out, the protrusion of the mandible results in a mesial force application on the lower incisors; in the absence of lower lip pressure, this mesial force proclines the lower incisors with Twin-block treatment.

Molar changes were very variable. Toth and McNamara (3) appropriately suggested that the contrast of the findings could be due to the different measurement methods used: Mills and McCulloch (4) applied a custom analysis with a vertical line through Sella and perpendicular to palatal plane, whereas Lund and Sandler (10) used distance between cephalometric points S and N (SN) and SN perpendicular. Toth and McNamara (3) on the other hand used various constructed reference lines: a line tangent to pogonion and perpendicular to mandibular plane, lines perpendicular and parallel to Frankfort line at pterygomaxillary fissure, and lines parallel and perpendicular to mandibular plane at pogonion.

As for soft tissue changes, Morris *et al.* (13) emphasized that despite statistical significance, the large standard deviations of their findings make the clinical significance of the few soft tissue changes, such as lower lip position and length, questionable. Similarly, although Varlik *et al.* (14) reported statically significant changes for many of the investigated soft tissue landmarks, the clinical significance of their findings is highly questionable as, just like Morris (13), they found large variations in individual responses. On the other hand, despite no statistical significance, Morris *et al.* (13) reported a slight reduction of facial convexity with opening of the nasolabial angle and labiomental fold. These findings are in agreement with those of Varlik. Varlik *et al.* (14) suggested that uncurling of the lower lip that was initially trapped under the upper incisors could have contributed to the increase of the labiomental angle. Morris *et al.* (13) argued that the large individual variation of these angles and the low accuracy of soft tissue measurements preclude reaching statistical significance. They pointed out that employing larger sample sizes through multi-centre studies can address this issue, but it will introduce other sources of variability such as techniques and appliances. As for elongation of lower lip, it could be perhaps explained by the retraction of upper lip as a result of upper incisor retroclination (13,17).

Regarding the meta-analysis results, they only present a partial picture of all the data available as only 6 variables (SNA, SNB, Co-Gn, ALFH, U1-AnsPns, and L1-GoGn) were considered to have enough data to justify the procedure. In other words, although 10 studies were finally identified, only five presented data that were repeated in other studies. The summary of the skeletal findings is that the maxilla gets a very minor restriction in growth (0.8 degree), the mandible is projected slightly forward (1.2 degree), the mandibular body increments significantly (3 mm), and the anterior facial dimensions increase significantly (2 mm). The reason behind an increment in the mandibular dimensions, without a significant anterior projection, is the vertical component of the changes. These camouflage the impact of the mandibular body increment. At the dental level, significant changes were identified with reduction of upper incisor proclination (9.2 degree) and increase of the lower incisor inclination (3.8 degree). This is where the dental occlusal changes do manifest themselves. This is also where the patient likely perceived the most significant change of the treatment.

The results of the present review should be interpreted with caution due to the limitations of both the review and the included studies.

The included studies have used various measurements, some linear and some angular, to quantify the mandibular dimension, mandible's sagittal position, and incisors position. The variability of the selected measurements makes it challenging to compare the findings of the studies. Moreover, some of the used measurements do not actually represent what the authors wanted to evaluate. For example, despite its limitations, SNB was used in most studies to evaluate sagittal position of mandible. However, this angle does not account for rotational changes of mandible and changes of lower anterior face height. Therefore, changes in face height have potentially masked or exaggerated the true sagittal changes. Furthermore, all studies only evaluated the short-term effects; therefore, the long-term treatment outcome continues to be a topic of controversy with functional Class II correctors.

It is very important to factor out dentoalveolar and skeletal changes that will normally occur without treatment. The use of a control group from the same population where the treatment group is taken from is the ideal situation. This can be done in randomized clinical trials. In the absence of a similar control group, the use of historical controls is the next best choice for retrospective clinical trials. Limitations such as differences in craniofacial growth because of secular trends should be considered. Those differences are in general of questionable clinical significance.

Treatment times among the included studies were between 8 and 16 months. In clinical practice, this time frame does include not only the Class II correction but also a period of time where no more Class II correction is sought but the last months were for vertical dentition management or retention until a second phase could be started. By annualizing the data, it is assumed that Class II effects were linear from treatment start to finish. This is unlikely. Therefore, the conclusions may be wrong due to the highly heterogeneous and biased studies.

It was not possible to analyse the effect of the skeletal maturation stage on the reported changes due to the limited data available.

A limitation of conducting meta-analysis when significant data heterogeneity exists is that the average reported values of change are not likely the ones that will happen in any individual patient. Caution should be exercised in this regard when applying our results into clinical practice.

Finally, the Twin-block appliance can be customized so that it addresses individual patient's needs. In these cases, the current results will not apply.

Conclusions

- Proclination of lower incisors, retroclination of upper incisors, distal movement of upper molars and/or mesial movement of lower molars, increase in mandibular length, and/or forward movement of the mandible were consistently reported.
- Clinically significant restraint of maxillary growth was not found. Although the mandibular body length is increased, the facial impact of it is reduced by the simultaneous increment of the face height.
- Changes of lower face height and occlusal plane inclination varied, suggesting that vertical dimension can be manipulated in patients who would benefit from lower molar extrusion.
- As for lip position, findings were controversial and there is not enough evidence to suggest clinically meaningful changes of lip position.
- No long-term changes were available. Therefore, the future impact of these changes in the growing faces is unknown.

Supplementary material

Supplementary material is available at *European Journal of Orthodontics* online.

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