Twin-block appliance promotes condylar remodeling in patients with Class II malocclusion: a systematic review

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Abstract

Background: To evaluate the changes of condylar in patients with Class II malocclusion treated with Twin-block appliance. **Methods:** Six electronic databases, including PubMed, Embase, Cochrane library, Chinese Biomedical Literature Database, China National Knowledge Infrastructure and VIP Database were searched until October 15, 2019 without language restrictions. Randomized controlled trials (RCTs) and clinical controlled trials (CCTs) reporting condylar changes produced by Twin-block appliance in Class II malocclusion patients were included. Literature filtering, data extraction, and methodological quality assessment were finished by two reviewers independently. Meta-analysis was performed with Review Manager (version 5.3; Nordic Cochrane Centre, Cochrane Collaboration, Copenhagen, Denmark). For continuous data, the mean difference and their 95% confidence intervals were used for statistical pooling. **Results:** Three studies with a total of 100 patients were included (1 RCT and 2 CCTs). The meta-analysis indicated a significant increase of condylar dimensions after Twin-block treatment in Class II malocclusion patients, including 0.91mm in height, 1.03mm in width, and 1.08mm in length. There were statistically significant increments in the superior and posterior joint spaces and no significant change in the anterior joint space. **Conclusions:** Twin-block appliance promotes the remodeling of condylar and stimulates forward and downward movement of condylar. Further high-quality studies with large samples and long-term evidence are still required to obtain more reliable conclusions. **Keywords:** Twin-block appliance; Class II malocclusion; Temporal Mandibular Joint; Systematic review; Meta-analysis

Background

Characterized by distal molar relationship, convex profile and mandibular retrusion, Class II malocclusion is a common dentofacial deformity that greatly affects the facial appearance, oral function and psychological health of patients. Either mandibular deficiency or maxillary excess or even both can be the mechanism of Class II malocclusion, resulting in the sagittal discrepancy of upper and lower jaws.[1] The solution for an adult with skeletal sagittal discrepancy seeking for orthodontic treatment is orthognathic surgery or orthodontic camouflage. However, for a child or teenager at rapid growth stage, Class II functional appliances are recommended,[2] because they can make the best of growth potential and generate pressure on the skeletal and dental structures as well as muscles and soft tissues to promote skeletal growth modification and tooth movement.[3] The Twin-block appliance is one kind of removable Class II functional appliances, invented by professor Clark in 1982.[4] Composed of two separate removable acrylic bite blocks and occlusal inclined planes trimmed to an angle of 70 degrees, Twin-block appliance is small and tolerable for patients to wear all day, promising a relatively satisfying treatment outcome.

To date, the changes of dentofacial structures and soft tissues produced by Twin-block appliance have been clarified by sufficient studies.[5-10] However, reliable scientific evidence about the effects on the temporomandibular joint (TMJ) of Twin-block appliance is insufficient, with a few articles reporting conflicting results. Some studies reported that Twin-block appliance enables forward movement of the condylar and promotes new bone deposition on the condylar.[5, 11-14] However, some studies found that

the treatment effects of Twin-block appliance on TMJ, such as changes of joint spaces, were small. [15] Therefore, it is of great significance to critically evaluate the corresponding studies by systematic evidence-based review, to provide more accurate and reliable conclusions about treatment effects of Twin-block appliance on TMJ in Class II malocclusion patients, especially in terms of condylar position and dimensions.

Methods

The PRISMA statement was used as the basis for reporting the systematic review findings. The protocol for this systematic review was not registered.

Criteria for inclusion and exclusion

The inclusion criteria were as follows:

1. Participants: growing patients with Class II malocclusion
2. Intervention: growing patients treated with Twin-block appliance, with non-extraction or non-surgical approach to prevent interference of confounding factors
3. Control: growing patients with Class II malocclusion receiving no treatment or fixed appliance treatment
4. Outcome: using MRI or CBCT to evaluate the displacement and modification of condylar
5. Study: randomized clinical trials(RCTs) and prospective controlled clinical trials(CCTs)

Studies were excluded according to the following criteria:

1. Studies of patients with cleft lip and/or palate and craniofacial syndrome
2. Studies without control group
3. Intervention with any other orthodontic treatment or surgical treatment
4. Outcomes without data on TMJ
5. Abstracts, commentaries, descriptive studies, individual case reports, series of case, retrospective studies, reviews and meta-analysis

Search strategy

PubMed, Embase, Cochrane library, Chinese Biomedical Literature Database, China National Knowledge Infrastructure and VIP Database were searched on October 15, 2019 without limitations on language. The specific search strategies are shown in Table 1. Two reviewers independently screened titles and abstracts first to select potentially eligible studies after elimination of duplicates. Next, full texts were obtained to confirm their eligibility. Any disagreements were resolved by discussion. (**Table 1**).

Quality assessment

The risk of bias (RoB) of included RCT study was assessed according to the Cochrane Handbook for Systematic Reviews of Interventions[16] with the software Review Manager (version 5.3; Nordic Cochrane Centre, Cochrane Collaboration, Copenhagen, Denmark). For each article, the following domains were examined: (1) sequence generation; (2) allocation concealment; (3) blinding of participants, personnel, and outcome assessors; (4) incomplete outcome data; (5) selective outcome reporting; and (6) other sources of bias. The risk of bias for each domain was judged as low, high, or unclear risk. And each study was assigned an overall risk of bias rating: low risk (low for all aspects), high risk (high for ≥ 1 aspect), or unclear risk (unclear for ≥ 1 aspect). Meanwhile, a quality score was calculated by a modified version of the method described by Jadad[17].

The Newcastle-Ottawa Scale was used for quality assessment of CCTs. For each study, 3 domains were examined: (1) the selection of the study groups; (2) the comparability of the groups; (3) the ascertainment of the outcome of interest. By this “star system”, each study was evaluated as high quality (its score was ≥ 6) or low quality (its score was < 6). The risk of bias and quality assessment was performed by two reviewers. Any disagreement was resolved after consulting another author.

Data extraction

The data extraction form was developed by two reviewers independently, including the following items: the first author's name and year of publication; study type; sample size; age and gender of participants; duration of treatment; measurement method; mean observation period; and outcomes. Any obscure or missing data were obtained by contacting authors.

To evaluate the changes of condylar dimensions, we collected data on its height, width and length after treatment of Twin-block appliance. Data on the anterior, superior and posterior space were extracted and collected to evaluate changes of condylar position. Moreover, sagittal concentricity[18] also reflected the changes of condylar position. It was calculated from the formula: $R = [(P - A) / (P + A)] * 100\%$ (P: the narrowest posterior space; A: the narrowest anterior space). A zero value was referred to “concentric position”, positive values indicated an anterior position and vice versa.

Statistical analysis

RevMan 5.3 was used for the meta-analysis of quantitative data. For continuous data, the mean difference and their 95% confidence intervals were used for statistical pooling. The statistical significance of the hypothesis test was set at $P < 0.05$ (2-tailed z tests). Heterogeneity across studies was evaluated by the I^2 statistic. The random-effects model was employed for meta-analysis if heterogeneity was high ($I^2 > 50\%$). If the data could not be pooled, then they were described. When more than 10 studies were included, Funnel plots and the Begg's rank correlation test[19, 20] would be used to evaluate publication bias.

Results

Description of included studies

A total of 254 articles were remained after removing duplicates from 263 initial identified citations. After screening the titles and abstracts, full texts of 13 studies were retrieved for final consideration, among which 10 studies were eliminated for specific reasons. Finally, 3 studies [5, 11, 15] were included in the meta-analysis (**Fig 1**).

Quality of included studies

The RCT was of low quality with high risk of bias. And with the scores ranging from 6 to 8 respectively, the 2 CCTs were assessed as high quality according to the Newcastle-Ottawa scale. The detailed results of the quality assessment are shown in the Table 3 and Table 4 (**Table 3, Table 4**).

Synthesized results of treatment effects

Two studies reported changes of condylar dimensions.[5, 15] Because Elfeky et al reported both left and right condylar changes after treatment, we extracted data of both sides as well for meta-analysis. A forest plot is demonstrated in Figure 2, showing that there were significant changes of 0.91mm in height (mean difference: 0.91mm; 95%CI: 0.36 to 1.46mm; $P=0.001$; $I^2=0\%$), 1.03mm in width (mean difference: 1.03mm; 95%CI: 0.55 to 1.50mm; $P<0.0001$; $I^2=0\%$), and 1.08mm in length (mean difference: 1.08mm; 95%CI: 0.13 to 2.03mm; $P=0.03$; $I^2=30\%$) (**Fig 2**).

Two studies reported the effects of Twin-block appliance on the anterior, superior and posterior joint space. [5, 15] We also extracted data of both sides of patients in Elfeky's study for this meta-analysis. The meta-analysis revealed that there was no significant change in the anterior joint space (mean difference: -0.15mm; 95%CI: -0.48 to 0.19mm; $P=0.39$; $I^2=68\%$). However, superior joint space increased with statistically significance (mean difference: 0.70mm; 95%CI: 0.43 to 0.97mm; $P<0.00001$; $I^2=0\%$), as well as posterior joint space (mean difference: 0.29mm; 95%CI: 0.03 to 0.56mm; $P=0.03$; $I^2=0\%$) (**Fig 3**). Because of the high heterogeneity between two studies reporting the sagittal concentricity ($I^2=90\%$), meta-analysis was infeasible. Chavan et al[11] reported that after 6 months of treatment, the comparison of sagittal concentricity mean values showed a highly significant difference between the control group($6.7\%\pm 4.9\%$) and Twin-block group($18.7\%\pm 10.3\%$), indicating anterior displacement of condylar. While study by Mai et al[15] reported no significant difference between the control group($4.55\%\pm 4.69\%$) and Twin-block group($4.38\%\pm 5.34\%$).

Discussion

In this meta-analysis, only 3 studies were included (1 RCT and 2 CCTs).[5, 11, 15] RCTs have been recommended for comparison of different treatment approaches. However, due to difficulties in gathering many patients with specific included criteria, ethical problems of leaving patients with malocclusions untreated and absent blinding of patients and orthodontists, RCTs in orthodontics are lacking. Thus, the controlled clinical trials should be considered in a systematic review to enrich evidence for the treatment effects of orthodontic appliances. Moreover, the selection of studies with untreated patients as controls allows the assimilation of the outcomes of CCTs and RCTs to some degree. Combination of misleading

results in poorly-designed studies can result in misleading estimates of the true effect which is of little significance to researchers and clinicians.[10] So 5 before-after studies [13, 14] were excluded because of the lack of control groups which will limit the validity of meta-analysis. Inclusion of the control group without any treatments ensures that the changes of TMJ were only the results of treatment with Twin-block appliance instead of effects of growth. Moreover, the small number of included articles indicates the reality that studies investigating the TMJ changes during treatment of Twin-block appliance were far less than reporting the dentofacial and soft tissue changes.

In orthodontic practice, cephalometric and panoramic radiographs are the most common approaches for the evaluation of TMJ.[20-23] But changes of patients' head position and beam projection angle can lead to anatomic superimposition, affecting the validity of 2D image.[24] Therefore, conventional imaging systems do not lend themselves to detailed study of TMJ structures. Fortunately, recent development of CBCT and MRI avoids these drawbacks and makes the measurement of both hard and soft tissues of TMJ more convenient and reliable.[25, 26] So the inclusion of studies using CBCT and MRI instead of cephalometric radiographs to evaluate TMJ changes after treatment assures the accuracy of reported outcomes.[27] Moreover, the data extracted for meta-analysis were all measured by CBCT, to avoid misleading results resulted from the difference between CBCT and MRI.

The normal position of condylar is generally located in the center of the articular fossa with a certain variation range of -12 to +12 percent.[20, 31, 32] Nevertheless, Class II malocclusion patients were reported to possess anteriorly positioned condyles[33, 34] due to greater posterior fossa displacement and condylar growth problems. According to the results of this meta-analysis, superior and posterior joint spaces significantly increased with 0.70mm and 0.29mm respectively, which indicated the forward and downward displacement of condylar caused by treatment of Twin-block appliance. Chavan's study[11] confirmed this conclusion by reporting positive values of sagittal concentricity. Chintakanon's study[12] about sagittal concentricity also reported similar results that condylar position was evenly distributed in the pretreatment MRIs, but anterior condylar positions were in the majority (75%) after 6 months of treatment. But the included studies of this meta-analysis only reported short-term results after treatment. Some researchers insist that displacement of condylar during treatment with functional appliances is transient. Several studies about Herbst appliance[22, 34, 35] have demonstrated that altered condylar/fossa relationships may be present at the end of treatment but would restore during retention period. The results are similar to those reporting the treatment effects of Activator and Frankel appliance.[23, 33, 36] However, Chintakanon's study[12] of Twin-block appliance reported that the position of condylar relative to the fossa 6 months after treatment was still anterior to pretreatment, although the condyles appeared to be reseated in their fossae. In view of the lack of studies with long-term follow-up, the final changes of condylar position produced by Twin-block appliance remains uncertain. Complex factors including the growth of condylar, remodeling of articular fossa and even the growth of middle skull base will have an effect on the position of condylar. Therefore, further studies are still required for more deeply understanding of Twin-block treatment effect on joint spaces.

There are some limitations in this review, although normalized process of meta-analysis was conducted carefully. First, only 2 studies were included in the meta-analysis thus limiting the reliability of the results. Second, we failed to carry out a sensitivity analysis between RCT and CCT due to the lack of studies met inclusion criteria. Third, the quality assessments of included studies are not satisfying because of the selection bias and unsuccessful blinding of patients and orthodontists. Fourth, the statistical power was also limited by the small simple size of each study. Moreover, long-term follow-up of patients is greatly required to obtain more reliable conclusions.

Therefore, the results of the present review should be interpreted and applied with caution and more high-quality studies are required to obtain more reliable conclusions.

Conclusions

This systematic review showed that Twin-block appliance promoted the remodeling of condylar with the increase of height, length as well as width. Forward and downward movement of condylar was observed after treatment of Twin-block appliance. More high-quality studies with large sample and long-term effect of Twin-block appliance on TMJ remains unknown due to the lack of long-term follow-up results.

List Of Abbreviations

TMJ: Temporomandibular joint; MRI: Magnetic Resonance Imaging; CBCT: Cone Beam Computed Tomography; RCT: Randomized clinical trials; CCT: Controlled clinical trials.

Declarations

Ethics approval and consent to participate

Ethical approval and consent to participate are not applicable because the results are based on previously published papers.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are included in the study, and additional datasets are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Not applicable.

Authors' contributions

JCX and LX were involved in the design of the work. LX developed and conducted the search strategy. JCX and LX were involved in the screening the retrieved articles for their eligibility and data analysis. All authors contributed to the interpretation of the findings. JCX and YYY were major contributors in writing the manuscript, with substantive revisions from all remaining authors. All authors read and approved the final manuscript.

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Tables

Table 1. Search Strategies for Each Database

Database	Search Strategy
Medline(PubMed)	("Angle Class II malocclusion" OR "Class II malocclusion" OR "mandibular retraction" OR "mandibular deficiency") AND ("Orthodontic Appliances, Functional" OR "Functional Appliance" OR "Twin-block appliance") AND ("Temporomandibular Joint" OR "TMJ" OR "Jaw Joint" OR "Condylar")
Embase	("Angle Class II malocclusion" OR "Class II malocclusion" OR "mandibular retraction" OR "mandibular deficiency") AND ("Orthodontic Appliances, Functional" OR "Functional Appliance" OR "Twin-block appliance") AND ("Temporomandibular Joint" OR "TMJ" OR "Jaw Joint" OR "Condylar")
Cochrane library	("Angle Class II malocclusion" OR "Class II malocclusion" OR "mandibular retraction" OR "mandibular deficiency") AND ("Orthodontic Appliances, Functional" OR "Functional Appliance" OR "Twin-block appliance") AND ("Temporomandibular Joint" OR "TMJ" OR "Jaw Joint" OR "Condylar")
CBM	("Angle Class II malocclusion" OR "mandibular retraction" OR "mandibular deficiency") AND ("Functional Appliance" OR "Twin-block appliance") AND ("Temporomandibular Joint" OR "Condylar")
CNKI	("Angle Class II malocclusion" OR "mandibular retraction" OR "mandibular deficiency") AND ("Functional Appliance" OR "Twin-block appliance") AND ("Temporomandibular Joint" OR "Condylar")
VIP	("Angle Class II malocclusion" OR "mandibular retraction" OR "mandibular deficiency") AND ("Functional Appliance" OR "Twin-block appliance") AND ("Temporomandibular Joint" OR "Condylar")

Table 2. General Information of the Three Included Studies

Study	Study Type	Sample Size (Drop Out; TG/CG)	Age (years)	Gender (M/F)	Duration of Treatment	Measurement Method	Measuring Time Point	Outcome
Chavan et al 2014[11]	Prospective; CCT	30 (0;10/10/10)**	9~14; mean: 11.5	13/7	6 months	MRI	Six months after treatment;	Significant forward positioning of the condylar
Elfeky et al 2018[5]	Prospective; CCT	22 (4;22/18)	10-13;	0/18	TG: 9.4±1.33 months; CG: 8.12±2.72 months;	CBCT	TG: after the functional phase period; CG: after 8 months of observation;	Significant forward positioning of the condylar; Significant change in the condylar dimensions;
Mai et al 2014[15]	Prospective; RCT	60 (0;20/20/20)***	Mean: 12	Unclear	TG: 10-14 months; CG: 16-25 months	CBCT	After treatment	Significant change of height and length in the condylar; No significant displacement of the condylar;

CCT indicates clinical controlled trials, RCT indicates randomized controlled trials, MRI, Magnetic resonance imaging, CBCT, Cone beam computer tomography, TG treatment group, CG controlled group.

Table 3. Risk of Bias of the included studies

Study	Item1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Overall Risk of Bias	Quality
Chavan et al 2014[11]	Unclear	Unclear	Low	Low	Low	Low	Low	Unclear	Moderate
Elfeky et al 2018[5]	Unclear	Unclear	Low	Low	Low	Low	Low	Unclear	Moderate
Mai et al 2014[15]	Low	Unclear	Low	Low	Low	Low	Low	Unclear	Very low

Item 1: Random sequence generation; item 2: Allocation Concealment; item3: Blinding of participants and Personnel; item4: Blinding of Outcome Assessment; item5: Incomplete Outcome Data; item6: Other Bias.

Table 4. Quality assessment of nonrandomized studies

Quality Evaluation	Study	
	Chavan et al 2014[11]	Elfeky et al 2018[5]
Representativeness of the Twin-block group	*	*
Selection of the control group	*	*
Ascertainment of Twin-block group	*	*
Demonstration that outcome of interest was not present at start of study	*	*
Comparability of participants on the basis of the design or analysis	*	**
Assessment of outcome with independent blinding		
Adequacy of follow-up		
Lost to follow-up acceptable(<10% and reported)	*	*
Total quality(score)	High(6)	High(7)

This table shows the quality assessment of nonrandomized studies. Each item received 1 star(*), except for comparability, which can receive 2 stars. The total number of stars represents the score.

Figures

Figure 1

Systematic search and selection strategy (flow chart)

Figure 2

Meta-analysis of the changes of condylar dimensions

Figure 3