Clinical Effectiveness of Different Types of Bone-anchored Maxillary Protraction for Skeletal Class III Malocclusion: Systematic Review and Network Meta-analysis

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Abstract

Objective

This study aimed to estimate the clinical effects of different types of bone-anchored maxillary protraction devices using network meta-analysis.

Methods

We searched seven databases for random and controlled clinical trials that compared bone-anchored maxillary protraction with tooth-anchored maxillary protraction interventions or untreated groups up to May 2021. After literature selection, data extraction and quality assessment, we calculated the mean differences, 95% confidence intervals and Surface Under the Cumulative Ranking (SUCRA) scores of eleven indicators (SNA, SNB, ANB, Wits, SNOr, SN/MP, ANS-Me, overjet, overbite, U1/PP, and IMPA). Statistical analysis was carried out using R statistical software through the GeMTC package based on the Bayesian framework.

Results

Six interventions and six hundred and sixty-seven patients were involved in eighteen studies. Compared to tooth-anchored groups, results showed more increases of SNA, ANB, Wits, SNOr and fewer increases of SN/MP, ANS-Me, and U1/PP in bone-anchored groups with a statistical difference. Compared to the control group, SNB decreased in all treated groups without any statistical difference. IMPA decreased in groups with facemasks and increased in other groups. SUCRA indicated that bone-anchorage with intermaxillary protraction (BAIP) caused the best effect in ANB, Wits, overjet and U1/PP.

Conclusions

Bone-anchored maxillary protraction can promote more forward movement of maxillary and correct the Class III intermaxillary relationship better, accompanied by less clockwise rotation of mandible and labial proclination of upper incisors. However, strengthening anchorage could not inhibit mandibular growth better and the lingual inclination of lower incisors caused by the treatment is related to the use of facemask.

Keywords: Class III treatment; Evidence-based orthodontics; Bone implant contact; Early treatment

Manuscript

1. Introduction

Skeletal Class III malocclusion is one of the most complex conditions encountered in the orthodontic clinic. The global prevalence of this condition in mixed and permanent dentition is 3.98% and 5.93%, respectively.[1] The pathogenesis of this form of malocclusion includes recession of the upper jaw, protrusion of the lower jaw, or the heteroplasia of both jaws. Almost two-thirds of cases with skeletal Class III malocclusion are accompanied by maxillary dysplasia.[2] Growth modification is the major purpose of orthopedic treatment for children with mild Class III malocclusion. Maxillary protraction is the preferred form of this treatment in the clinic and aims to reduce the possibility of orthognathic surgery in adulthood.[3]

Traditional maxillary protraction, which is also referred to as tooth-anchored maxillary protraction, transmits an orthopedic force to the maxilla indirectly through the dentition using intraoral retention devices, including banded[4] or bonded[5] Rapid Maxillary Expansion (RME) devices, to stimulate the growth of the maxillary sutures. This can promote the maxillary and inhibit the mandible effectively but is associated with side effects such as **labial** proclination of the maxillary incisors, clockwise rotation of the mandible, and an increase in the height of the lower third of the face due to the loss of anchorage.[6]

Along with the appliance of **mini-screws and miniplates** in the orthodontic clinic, the application of maxillary protraction with miniplates or **mini-screws** has developed rapidly and predominantly includes two types: miniplates placed into the zygomatic buttress areas that protract the facemask,[7] or protraction with **mini-screws** placed between the mandibular lateral incisors and canines using Class III intermaxillary elastic.[8] In a previous evidence-based study, Shi et al.[9] demonstrated that bone-anchored maxillary protraction presented less **labial** proclination of the upper incisors when compared with the tooth-anchored type, thus indicating that skeletal anchorage could reduce the incidence of side effects.

Different types of modified skeletal anchorage devices have been applied for maxillary protraction in the orthodontic clinic,[10,11] including the Hybrid Hyrax RME appliance.[12] However, it is not clear whether appliances that combine tooth- and bone-anchorage provide better treatment effects than those using bone-anchorage. Furthermore, we have yet to ascertain whether devices with stronger anchorage just induce the undesired dental compensation or provide more skeletal effects at the same time.

Compared to pair-wise meta-analysis, network meta-analysis (NMA) provides the option to compare the effects of numbers of interventions.[13] In this study, we aimed to compare the clinical effects of different types of bone-anchored maxillary protraction with tooth-anchored maxillary protraction through NMA and ranked the **recommended** sequence of these interventions to provide practical clinical reference guidelines.

2. Materials and Methods

2.1 Registration and Literature Search

This systematic review and network meta-analysis were registered in International Prospective Register of Systematic Reviews (ID: CRD42021243210). Searches were performed using seven databases: MEDLINE (PubMed), Embase, Cochrane, Web **of** Science, Scopus, China National Knowledge Infrastructure, and the Wanfang Database. Gray literature was searched through Google Scholar. The search terms (Appendix 1) combined subject terms and free terms without language limitations. The search date was up to May 15th, 2021.

The English subject terms included extraoral traction appliances, malocclusion, angle Class III, and orthodontic anchorage. The free terms included maxillary protraction, reverse headgear, anterior crossbite, and skeletal Class III.

2.2 Inclusion and Exclusion Criteria

The inclusion criteria were as follows: (1) Population: **children** with Class III malocclusion, ANB<0°(° , the angle composed by point Subspinale-Nasion-Supramentale), edge-to-edge or reverse anterior bite, inability to retract the mandible; (2) Intervention: a bone-anchored device for the experimental group and a tooth-

anchored device or blank for the control group, or different types of bone-anchored device for the experimental and control groups; (3) Outcome: including the primary outcomes, SNA (° , the angle composed by point Sella-Nasion-Subspinale), SNB (°, the angle composed by point Sella-Nasion-Supramentale), ANB; (4) Study design: randomized controlled trial (RCT) or controlled clinical trial (CCT).

The exclusion criteria were as follows: (1) history of surgery, orthodontic or orthognathic treatment; (2) presence of cleft lip and palate or other maxillofacial deformities; (3) presence of other genetic or systemic diseases.

2.3 Literature Selection, Data Extraction and Quality Assessment

Following pre-experimental training, two researchers completed the literature selection, data extraction and quality assessment independently according to the specific inclusion and exclusion criteria. Another researcher made the final decision if controversy arose when cross-checking the results.

The data extraction mainly included publication information, basic information of the study subjects, interventions, and outcomes. The quality assessment of the included RCTs was performed using the Risk of Bias (ROB) tool recommended by Cochrane. The same assessment of CCTs was performed using the Newcastle-Ottawa Scale (NOS).

2.4 Statistical Analysis

The data were analyzed by R statistical software (R version 3.6.3) through the GeMTC package based on the Bayesian generalized linear model, setting the number of pre-iterations to 10,000, the number of iterations to 50,000, the number of Markov chains to 3, and the step size to 1. The Weighted Mean Difference (WMD) was chosen as the effect size with 95% confidence intervals (CI).

A network plot was drawn to depict the direct relationship among interventions. One point presented one type of intervention, and the size of the point represented the number of patients included in this intervention. The line segment between two points demonstrated the existence of a direct comparison between these two interventions. When a closed-loop existed in the network plot, this showed that direct and indirect comparison existed at the same time; therefore, the consistency analysis would be

applied. Consistency analysis between direct comparison and indirect comparison results was performed *via* node splitting. If P>0.05, the consistency model was chosen. The heterogeneity of the included studies was analyzed according to the I^2 calculation. P<0.05 or I^2>50% indicated that significant heterogeneity existed and sensitivity analysis would be carried out to identify the source of heterogeneity. The random-effects model was applied for each indicator to take inter-study differences into account.

Potential Scale Reduction Factors (PSRF) was used to judge the degree of convergence of the model. The closer the PSRF was to 1, the more stable the model and the more credible the results were. If PSRF>1.1, then the number of simulations would be increased until the PSRF was closer to 1.

The rank of the interventions was evaluated by Surface Under the Cumulative Ranking (SUCRA) by Stata (version 14.0; Statacorp, College Station, Texas). SUCRA ranges from 0 to 100. The closer to 100 the value is, the larger the probability of the intervention being the most optimal. The publication bias was tested using the funnel plot as generated by Stata.

Our study involved a total of eleven outcomes: SNA, SNB, ANB, Wits (mm, the distance between the perpendicular of the Subspinale and Supramentale point to the occlusal plane), SNOr (°, the angle composed by point Sella-Nasion-Orbitale), SN/MP (°, the angle composed by point Sella-Nasion plane and the mandibular plane), ANS-Me (mm, the distance between the perpendicular of the Anterior Nasal Spine and Menton to the Frankel plane), U1/PP (°, the angle composed by the axis of upper incisors and the palatal plane), IMPA (°, the angle composed by the axis of lower incisors and the mandibular plane), overjet and overbite (Figure 1).

3. Results

3.1 Literature searches

According to the search formula shown in Appendix 1, 1374 relevant studies were retrieved from all search sources. Fifty-six duplicate studies were removed through EndNote X9. Two hundred and eighty-three studies that did not correspond with the inclusion criteria were excluded by title and abstract. After reading the full text of the

35 studies, 18 studies (four RCTs[11,14-16] and 14 CCTs[4,7,8,10,12,17-25]), involving a total of 667 patients were finally included. The PRISMA Flow Diagram is given in Figure 2.

3.2 Study characteristics

Table 1 shows the essential characteristics of the included studies. In this study, interventions that only used bone-anchorage such as mini plates or mini screws were classified as a bone-anchored group, including bone-anchorage with facemask appliance (BAFM) and bone-anchorage with intermaxillary protraction (BAIP). Interventions that combined bone-anchorage and bond or bands were classified as a mixed-anchored group, including mixed-anchorage with a facemask (MAFM) and mixed-anchorage with intermaxillary protraction (MAIP). Detailed descriptions of the interventions are listed in Table 2 and Appendix 2.

3.3 Risk of bias within studies

Results arising from our methodological quality are shown in Appendix 3. The quality of the RCTs ranged from low to unclear: two studies[11,14] were graded as low risk and two studies[15,16] were graded as unclear risk. Quality assessment of the CCTs ranged from good to satisfactory: ten studies[4,8,10,17-20,22,24,25] were graded as good and four studies[7,12,21,23] were graded as satisfactory. The bias was mainly related to non-random study designs.

3.4 Network meta-analysis results

The network plot of each indicator had closed loops (Figure 3). Pair-wise results are shown in Appendix 4. The major results of the network meta-analysis are shown in Figure 4.

3.4.1 Skeletal changes

We identified 18 trials, including 667 patients adopting SNA, SNB and ANB as endpoints and 11 trials including 384 patients adopting Wits as endpoints. Compared with the FM group, SNA (Figure 4a), ANB (Figure 4c) and Wits (Figure 4d) in the bone-anchored groups exhibited more advancement than those in the mixed-anchored groups. SUCRA value (Table 3) showed that BAFM caused the most advancement of

the A point and that BAIP had the best effect in terms of improving ANB and Wits. The increase of SNB (Figure 4h) was significantly inhibited in the treated group when compared to the CONTROL group, and the effects between the treated group presented with no significant difference (Figure 4b).

Five studies, including 193 patients, adopted SNOr as the outcome. Compared to the CONTROL group, SNOr (Figure 4k) was higher in the treated groups. These changes were most apparent in the bone-anchored group than in the FM group. SUCRA also indicated that BAIP resulted in the best effect in terms of increasing the SNOr.

Fourteen studies, including 493 patients, adopted SN/MP as the outcome. Compared to the FM group, SN/MP (Figure 4f) in the bone-anchored groups showed a lower increase than the mixed-anchored groups. SUCRA implied that BAIP might be the best option for inhibiting the increase of SN/MP.

Seven studies, including 284 patients, adopted ANS-Me as the outcome. ANS-Me (Figure 4e) increased in each treated group compared to the CONTROL group and the changes caused by BAFM and MAFM were significantly less extensive than those caused by FM.

3.4.2 Dental changes

Nine studies, including 284 patients, adopted U1/PP as the outcome indicator. Compared to the FM group, U1/PP (Figure 4g) in the bone- and mixed-anchored groups showed a lower increase (MD_{BAFM}=-3.3, MD_{BAIP}=-2.2, MD_{MAFM}=-2.8, MD_{MAIP}=-0.45). SUCRA indicated that BAIP was the most effective intervention with regards to controlling the labial proclination of the maxillary incisors.

Fifteen studies, including 534 patients, adopted IMPA as the outcome indicator. Compared to the CONTROL group, IMPA (Figure 4l) was reduced in groups that utilized a facemask (MD_{FM}=-4.6, MD_{BAFM}=-4.2, MD_{MAFM}=-0.56), while a different degree of increase was observed in the groups that were facilitated by intermaxillary traction (MD_{BAIP}=0.72, MD_{MAIP}=6.1).

Twelve studies, including 437 patients, adopted overbite and overjet as the outcome indicators. Our statistical results showed that all types of maxillary protraction resulted in an increased overjet (Figure 4j) and a reduced overbite (Figure 4i).

3.5 Heterogeneity tests, inconsistency tests and other results

The heterogeneity test showed statistical heterogeneity existed between the included studies for the outcome indicators (I^2>50%); therefore, the random-effects model was applied. Node-splitting methods showed that inconsistency existed for SNA, SNB, ANB, Wits, SN/MP and IMPA (P<0.05). Sensitivity analysis was applied to identify the source of inconsistency. This inconsistency was removed after excluding two studies[14,17] from the analysis of SNA and SN/MP, respectively. Inconsistency also existed for SNB, ANB, wits, and IMPA; this inconsistency was also eliminated after excluding the study by *Sar 2014* (P>0.05).[19] The results after sensitivity analysis were the same as the results of network meta-analysis, thus indicating the stability of our statistical results. Furthermore, the funnel plots (Appendix 5) were symmetrical, thus indicating that the level of publication bias was acceptable. PSRF values for all indicators were equal to 1, thus indicating that our results were stable.

4. Discussion

Studies have shown that maxillary protraction could present obvious effects in correcting the maxilla deficiency of skeletal Class III children.[6] To reduce the side effects caused by the loss of anchorage, clinicians have used a variety of different methods combined with skeletal anchorage. Thus, it is vital to evaluate the clinical effects of these approaches and verify the preferred device for the clinic. Due to the diversity of clinical cases, such as cases with palatal transversal disharmony, it is difficult to design trials that apply only maxillary protraction devices. Both Foersch et al.[26] and Lee et al.[27] evaluated the effect of maxillary protraction with or without RME over short- and long-terms but failed to identify any significant differences. Therefore, we did not use subgroupings in our analysis according to whether RME appliances were used. Our study investigated the influence of different anchorage strengths on the effects of maxillary protraction *via* evidence-based medical methods.

Results of our study showed that stronger anchored maxillary protraction could promote more anterior movement of the maxilla and significantly correct the intermaxillary Class III relationship better than a traditional tooth-anchored appliance. Bone-anchored devices which transmit orthodontic force to the maxilla directly could offer the best clinical effects; this was consistent with the findings of the previous studies.[4,8,9] BAFM could be the best way to promote the maxilla and BAIP could be the best method with which to correct the Class III intermaxillary relationship. Furthermore, we found that maxillary protraction improved the advanced movement of the orbitale point; this was consistent with the results of Elnagar et al.[14] and Lee et al..[18] This is the first time anyone has proven the effect of maxillary protraction on improving the growth of the upper half of the midface and correcting the concave profile of Class III patients through evidence-based medical methods.

Our results showed that maxillary protraction inhibited the sagittal growth of the mandible in the short-term. We also found that there was no significant difference between different anchored groups; this indicated that the restraint effects caused by the counterforce of the orthopedic force acting on the mandible and the mental region could only be influenced by the value of protraction force rather than anchorage strength. Furthermore, it has been generally accepted that mandibular growth is difficult to inhibit[28] and that overgrowth will relapse after the end of maxillary protraction.[3] Thus, maxillary protraction cannot be an ideal technique for inhibiting the mandible. The bone-anchored groups showed significantly less rotation because bone anchorage reduced elongation of the maxillary molars and the drop in the posterior palatal plane. Thus, the height of the lower face was less increased.

The labial proclination of the maxillary incisors was significantly reduced after strengthening the anchorage; this was consistent with the results of a previous study.[4] When stronger anchorage was applied, the dentition and the maxillary moved together rather than undergoing clockwise rotation; this was due to the reduction in labial force. Moreover, bone-anchored interventions led to more growth of the maxilla, thus providing more space to relieve the congestion, with less labial proclination of the incisors than others.

There are different opinions relating to the changes in mandibular incisors. Ito et al. found that during the treatment of skeletal Class III malocclusion in animal experiments, the lower incisors tended to decompensate for the anterior growth of the maxillary position.[29] However, a clinical study by Tripathi et al. concluded that the appliance of a chin-cup caused lingual inclination of the mandibular incisors.[23] We found that groups using facemasks all showed a more pronounced lingual inclination of the lower incisors, while groups using intermaxillary elastics showed labial proclination. These results suggested that the lingual compensation of the lower incisors could be predominantly related to the chin-cup[30] instead of the undesired force produced by protraction.

The correction of overjet caused by maxillary protraction involved both dental and skeletal effects. According to our results, the proportion of skeletal effect was 57.87% in group FM, and the proportion increased to more than 90% in the BAIP; groups with intermaxillary protraction presented with more skeletal effects than those with facemasks. Class III intermaxillary elastics could help to correct the jaw position. This could be the reason for the presence of more skeletal effects. The stability of the change in jaw position depends on the adaptive reconstruction of the temporomandibular joint. If the articular fossa could not be modified in a timely manner, the compulsive mandibular retrusion might lead to compression of the bilaminar region. This could be a hidden danger for temporomandibular diseases. However, this process could also increase the possibility of relapse. Dentists should pay more attention to the symptoms of the temporomandibular joint and prolong the follow-up time when applying maxillary protraction with intermaxillary elastics.

There **were** some limitations in this study that need to be considered. Studies by Elnagar et al.[14] in 2016 and Sar et al.[19] in 2014 were designed as three-arm trials; all of the other included studies were two-arm trials. Variations in study design could be the source of the observed inconsistencies in SNA, SNB, ANB, Wits and IMPA. **Ağlarcl** et al.[17] applied bonded intra-oral devices in their study; this controlled the extrusion of the maxillary molars and regulated the rotation of the mandibular plane. This could be the underlying reason for the appearance of inconsistency in SN/MP.

Furthermore, the included studies lacked sufficient and uniform outcome indicators. It was also difficult to compare the initial malocclusion severity of the participants in an accurate manner. Also, the lack of randomization, the difference in treatment protocols, and the inconsistent development stages in children at the same age, could all induce heterogeneity. More high-quality and well-designed RCTs are now required to eliminate the effects of these variables and establish the true efficacy of the treatment.

5. Conclusion

Our analysis showed that bone-anchored maxillary protraction **could** significantly promote the forward movement of the maxillary and correct the Class III intermaxillary relationship. Strengthening the anchorage could gain more bone effects in terms of maxillary protraction and reduce dental compensations and side effects, including **the** labial proclination of the upper incisors, clockwise rotation of the mandibular bone, and an increase in the height of the lower face. Of the maxillary protraction interventions described in this study, BAIP was best able to gain treatment effect.

The lingual inclination of the mandibular incisors after maxillary protraction mainly relates to compression of the chin-cup. Maxillary protraction could also promote the forward growth of the middle third of the face and improve the concave profile in an effective manner.

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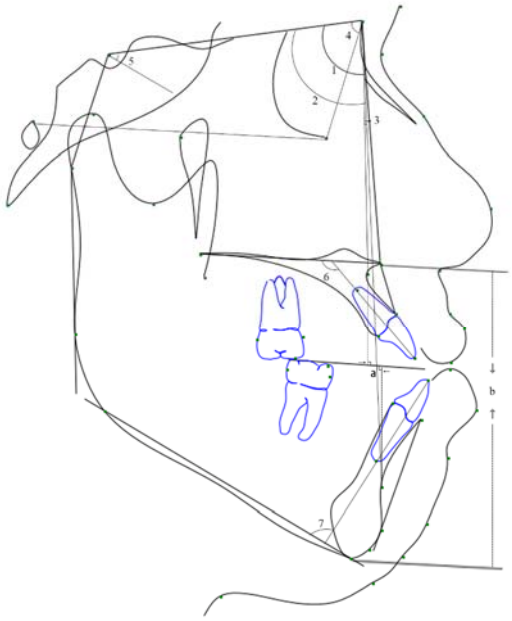
Figures

Figure 1 Description of the indicators



1.SNA the angle composed by point Sella-Nasion-Subspinale

2.SNB the angle composed by point Sella-Nasion-Supramentale

3.ANB the angle composed by point Subspinale-Nasion-Supramentale

4.SNOr the angle composed by point Sella-Nasion-Orbitale

5.SN/MP the angle composed by the Sella-Nasion plane and the mandibular plane

6.U1/PP the angle composed by the axis of upper incisors and the palatal plane

7.IMPA the angle composed by the axis of lower incisors and the mandibular plane

a. Wits the distance between the perpendicular of Subspinale and Supramentale point to the occlusal plane

b. ANS-Me the distance between the perpendicular of Anterior Nasal Spine and Menton to the Frankel plane

Figure 2 PRISMA Flow Diagram

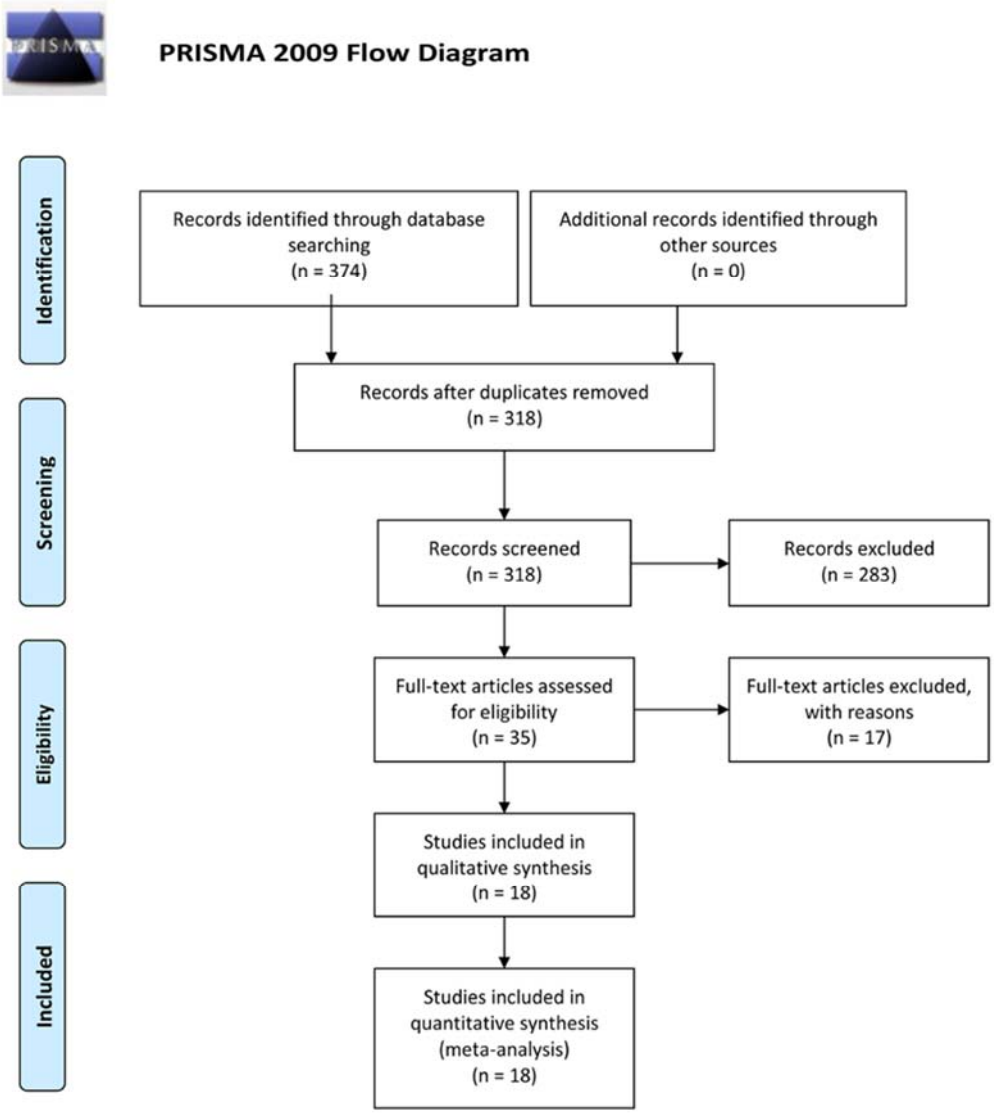
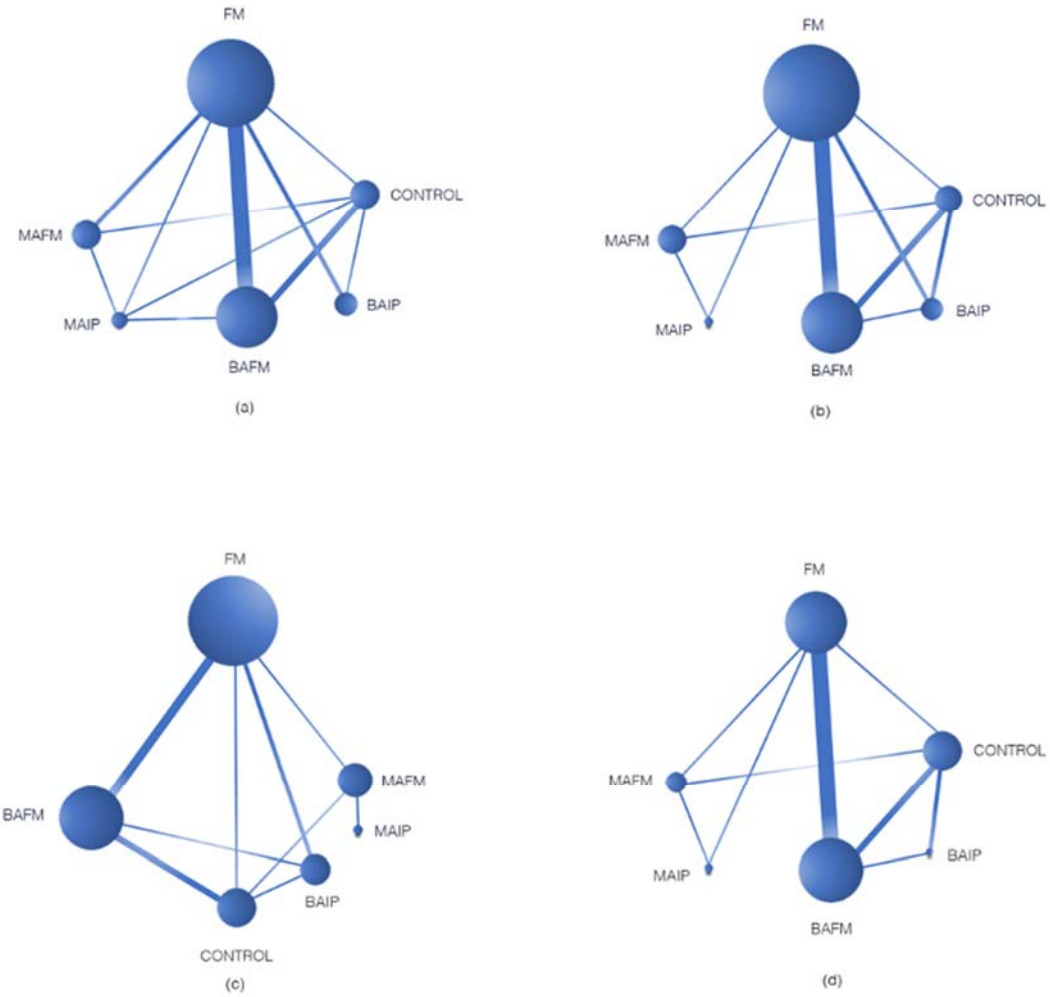
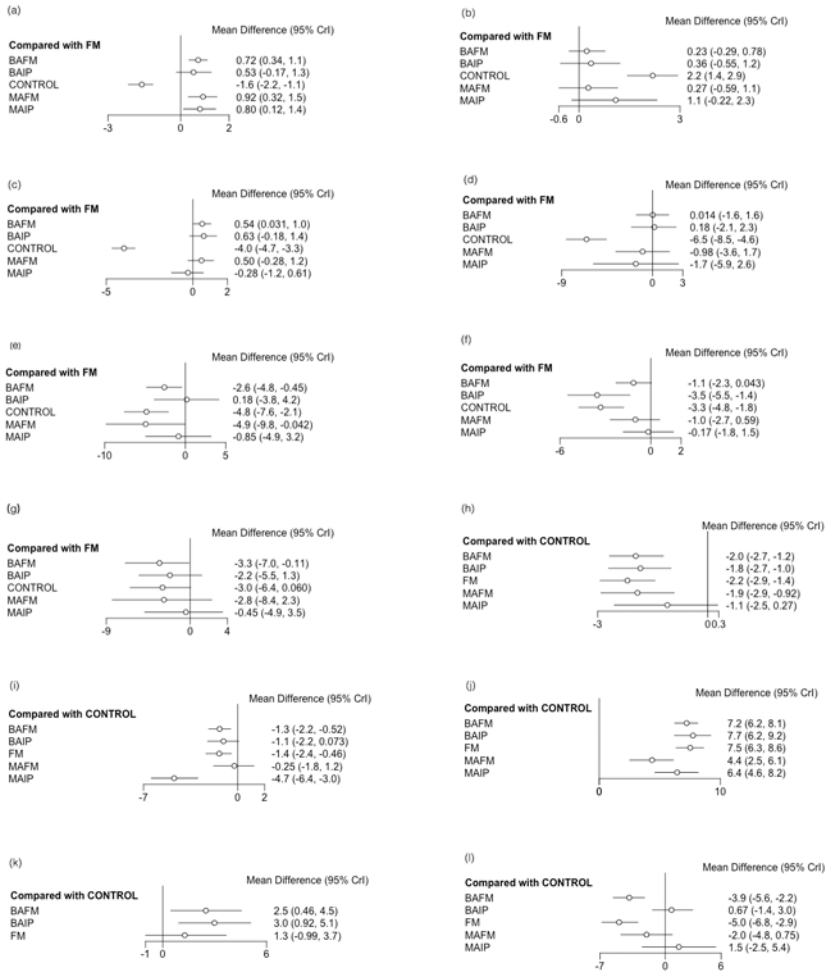


Figure 3 Network plot



(a) SNA (b) SNB (c) Wits (d) IMPA

Figure 4 Forest plot



Network meta-analysis compared with group FM (a)SNA; (b)SNB; (c)ANB; (d)Wits; (e)ANS-Me; (f)SN/MP; (g)U1/PP;

Network meta-analysis compared with group CONTROL (h)SNB; (i)Overbite; (j)Overjet; (h)SNOr; (l)IMPA.

Table 1 Characters of Included Studies

Author/year of publication	Design		Intervention	Sample		Age
					Sum	
Seiryu 2020[11]	2-arm	RCT	FM	20(8 f, 12 m)	39	10 years, 5 months ± 1 year, 8 months
			MAFM	19(7 f, 12 m)		11 years, 1 months ± 1 year, 3 months
Elnagar 2016[14]	3-arm	RCT	CONTROL	10(3 f, 7 m)	30	11.69±1.64 years
			BAFM	10(4 f, 6 m)		11.92±1.29 years
			BAIP	10(3 f, 7 m)		12.24±1.08 years
Ge 2012[15]	2-arm	RCT	FM	23(12 f, 11 m)	43	10 years, 6 months
			BAFM	20(11 f, 9 m)		10 years, 4 months
Abdolreza 2011[16]	2-arm	RCT	FM	10(7 f, 3 m)	20	10.5+1.5 years
			MAIP	10(5 f, 5 m)		11.3±0.8 years
Koh 2014[4]	2-arm	CCT	FM	28(21 f,7 m)	47	10.09 years (9.0~13.9 years)
			BAFM	19(11 f, 8 m)		11.21 years (9.1~13.0 years)
Erdal 2017[7]	2-arm	CCT	CONTROL	18(9 f, 9 m)	36	10.6 ± 1.12 years

			BAFM	18(10 f, 8 m)		11.4 ± 1.28 years
De 2019[8]	2-arm	CCT	FM	12(6 f, 6 m)	24	8±5.93 years
			BAIP	12(8 f, 4 m)		10±2.67 years
Lee 2012[10]	2-arm	CCT	FM	10(6 f, 4 m)	20	10.7±1.3 years
			BAFM	10(5 f, 5 m)		11.2 ±1.2 years
Ngan 2015[12]	3-arm	CCT	FM	20(12 f, 8 m)	60	9.8 ± 1.6 years
			CONTROL	20		9.0±1.8 years
			MAFM	20(12 f, 8 m)		9.6 ± 1.2 years
Eid 2016[22]	2-arm	CCT	CONTROL	10(3 f, 7 m)	20	9~12 years
			BAIP	10(5 f, 5 m)		9~12 years
Tripathi 2016[23]	2-arm	CCT	FM	10	20	9.90 ± 1.1 years
			BAFM	10		10.10 ± 1.1 years
Sar 2011[24]	3-arm	CCT	FM	15(7 f, 8 m)	45	10.31±1.52 years
			CONTROL	15(8 f, 7 m)		10.05±1.14 years
			BAFM	15(5 f, 10 m)		10.91±1.22 years
Nienkemper 2015[25]	2-arm	CCT	CONTROL	16(8 f, 8m)	32	9.4±1.1 years
			MAFM	16(6 f, 10 m)		9.5±1.6 years
Ağlarcl 2016[17]	2-arm	CCT	FM	25(13 f, 12 m)	50	11.21 ± 1.32 years

			BAIP	25(13 f, 12 m)		11.75 ± 1.23 years
Lee 2019[18]	2-arm	CCT	FM	27(12 f, 15 m)	46	11.21 ± 1.2 years
			BAFM	19(11 f, 8 m)		11.19 ± 1.1 years
Sar 2014[19]	3-arm	CCT	CONTROL	17	51	9.87±1.20 years
			BAFM	17		11.23±1.48 years
			MAIP	17		11.25±1.52 years
Willmann 2018[20]	2-arm	CCT	MAFM	17(9 f, 8 m)	34	8.74 ± 1.20 years
			MAIP	17(10 f, 7 m)		9.43 ± 0.95 years
Cha 2011[21]	2-arm	CCT	FM	25(15 f, 10 m)	50	10.8±0.9 years
			BAFM	25(16 f, 9 m)		11.0±1.4 years
Total	RCT/4		6	667		
	CCT/14					

Table 2 Description of Interventions

Group			Description
Control Group		CONTROL	Untreated Class III malocclusion children
Treated Group	Tooth-anchored Group	FM	Bond or banded intraoral devices protracted with facemask
	Bone-anchored Group	BAFM	Bone anchorages that placed on both sides of the lateral nasal walls, the posterior region, or zygomatic buttress areas of the maxilla protracted with facemask
		BAIP	Bone anchorages that placed on both sides of the maxillary posterior regions or zygomatic buttress areas, combined the bone anchorages placed in the mandibular anterior regions with intermaxillary Class III elastic
	Mixed-anchored Group	MAFM	Intraoral devices combined bond or bands with bone anchorages protracted with facemask
		MAIP	Intermaxillary Class III elastic between maxillary intraoral devices (combined bond or bands with bone anchorages) and bone anchorages in the mandibular anterior regions

Table 3 Surface Under the Cumulative Ranking Curve (SUCRA)

SUCRA	SNA	SNB	ANB	Wits	SNOr	SN/MP	ANS-Me	Overjet	Overbite	U1/PP	IMPA
CONTROL	0.0	7.1	0.0	0.0	14.3	91.9	85.9	0.0	92.9	59.0	64.7
BAFM	84.4	65.6	78.4	71.7	70.5	39.6	64.0	66.2	36.2	75.8	22.1
BAIP	71.3	73.6	82.2	76.0	95.5	74.0	20.1	87.5	53.4	80.5	81.6
MAFM	40.9	53.2	74.8	45.3		63.8	80.6	20.4	82.0	61.0	40.2
MAIP	69.1	14.2	27.2	35.3		18.9	31.3	45.4	0.0	9.3	88.7
FM	34.3	86.3	37.5	71.5	19.7	11.8	18.2	80.4	35.6	14.4	2.7

Appendix 1 Searching Queries and Results

	No.	Query	Results
Medline (Pubmed)	#1	((((((((((((extraoral traction appliances[MeSH Terms]) OR (maxillary protraction)) OR (reverse headgear)) OR (reverse head gear)) OR (protraction headgear)) OR (protraction head gear)) OR (headgear)) OR (head gear)) OR (facemask)) OR (face mask)) OR (mpa)) OR (delaire)) OR (class iii elastics)) OR (intermaxillary traction)	40,412
	#2	((((((((((((orthodontic anchorage procedures[MeSH Terms]) OR (orthodontic anchorage)) OR (miniscrew)) OR (mini screw)) OR (miniplate)) OR (bone screw)) OR (bone plate)) OR (skeletal anchorage)) OR (skeletal anchor)) OR (bone anchorage)) OR (bone anchor)) OR (mini plant)) OR (orthodontic anchor)	72,033
	#3	#1 AND #2	841
	#4	((((((((((((malocclusion, angle class iii[MeSH Terms]) OR (anterior crossbite)) OR (skeletal class iii)) OR (reverse occlusion)) OR (habsburg jaw)) OR (prognathism mandibular)) OR (hapsburg jaw)) OR (angle class iii)) OR (underbite)) OR (maxillary hypoplasia)) OR (mandibular hyperplasia)) OR (mandibular protrusion)) OR (maxillary restrusion)	103,436

	#5	((((((((randomized controlled trial[Publication Type]) OR (controlled clinical trial[Publication Type])) OR (randomized[Title/Abstract])) OR (placebo[Title/Abstract]))) OR (drug therapy[MeSH Subheading])) OR (randomly[Title/Abstract])) OR (trial[Title/Abstract])) OR (groups[Title/Abstract])	4,723,357
	#6	(animals[MeSH Terms]) NOT (humans[MeSH Terms])	4,682,411
	#7	#5 NOT #6	4,098,062
	#8	#3 AND #4 AND #7	105
Embase	#1	orthodontic anchorage'/exp OR 'orthodontic anchor'/exp OR 'orthodontic anchorage procedures' OR 'miniscrew'/exp OR 'miniplate'/exp OR 'bone screw'/exp OR 'bone plate'/exp OR 'skeletal anchorage' OR 'skeletal anchor' OR 'bone anchorage' OR 'bone anchor' OR 'mini implant'	49247
	#2	orthodontic headgear'/exp OR 'face mask'/exp OR 'extraoral traction appliances' OR 'maxillary protraction'/exp OR 'reverse headgear' OR 'protraction headgear' OR 'protraction head gear' OR facemask OR mpa OR delaire OR 'class iii elastics' OR 'intermaxillary traction'	54473
	#3	#1 AND #2	342

	#4	skeletal class iii malocclusion'/exp OR 'maxillary hypoplasia'/exp OR 'angle class iii' OR 'anterior cross bite' OR 'reverse occlusion' OR 'mandibular prognathism' OR 'mandibular hyperplasia' OR 'mandibular protrusion' OR 'maxillary restrusion' OR habsburg OR bapsburg OR underbite	2581
	#5	randomized controlled study' OR 'controlled study'/exp	7476641
	#6	#3 AND #4 AND #5	3
Cochrane	#1	(maxillary protraction) OR (reverse headgear) OR (reverse head gear) OR (protraction head gear) OR (protraction headgear) (Word variations have been searched)	96
	#2	(orthodontic headgear) OR (headgear) OR (head gear) OR (facemask) OR (face mask) (Word variations have been searched)	3342
	#3	(orthodontic face bow) OR (face bow) OR (mpa) OR (delaire) OR (class iii elastics) (Word variations have been searched)	2716
	#4	(intermaxillary protraction) (Word variations have been searched)	7

	#5	(orthodontic anchorage) OR (orthodontic anchor) OR (miniscrew) AND (miniplate) OR (bone screw) (Word variations have been searched)	2302
	#6	(bone plate) OR (skeletal anchorage) OR (skeletal anchor) AND (bone anchorage) OR (bone anchor) (Word variations have been searched)	2173
	#7	(mini plant) (Word variations have been searched)	107
	#8	MeSH descriptor: [Extraoral Traction Appliances] explode all trees	134
	#9	#1 OR #2 OR #3 OR #4 OR #8	5196
	#10	MeSH descriptor: [Orthodontic Anchorage Procedures] explode all trees	125
	#11	#5 OR #6 OR #7 OR #10	3100
	#12	MeSH descriptor: [Malocclusion, Angle Class III] explode all trees	115
	#13	(anterior crossbite) OR (skeletal class iii) OR (reverse occlusion) OR (habsburg jaw) OR (mandibular prognathism) (Word variations have been searched)	1646

	#14	(habsburg jaw) OR (angle class iii) OR (underbite) OR (maxillary hypoplasia) OR (mandibular hyperplasia) (Word variations have been searched)	736
	#15	(mandibular protrusion) OR (maxillary restrusion) (Word variations have been searched)	158
	#16	#12 OR #13 OR #14 OR #15	1916
	#17	MeSH descriptor: [Randomized Controlled Trial] explode all trees	119
	#18	MeSH descriptor: [Controlled Clinical Trial] explode all trees	128
	#19	(non-randomized trial) OR (randomized controlled study) OR (controlled clinical study) (Word variations have been searched)	1130390
	#20	#17 OR #18 OR #19	1060960
	#21	#9 AND #11	73
	#22	#21 AND #16 AND #20	22

Web of Science	#1	((((((((((TOPIC: (orthodontic anchorage) OR TOPIC: (orthodontic anchor)) OR TOPIC: (orthodontic anchorage procedures)) OR TOPIC: (orthodontic anchorage procedures)) OR TOPIC: (miniscrew)) OR TOPIC: (manipulate)) OR TOPIC: (bone screw)) OR TOPIC: (bone plate)) OR TOPIC: (skeletal anchorage)) OR TOPIC: (skeletal anchor)) OR TOPIC: (bone anchorage)) OR TOPIC: (bone anchor)) OR TOPIC: (mini implant))	226,759
	#2	((((((((((TOPIC: (orthodontic headgear) *OR* TOPIC: (face mask)) *OR* TOPIC: (extraoral traction appliances)) *OR* TOPIC: (maxillary protraction)) *OR* TOPIC: (reverse headgear)) *OR* TOPIC: (reverse head gear)) *OR* TOPIC: (protraction headgear)) *OR* TOPIC: (protraction head gear)) *OR* TOPIC: (facemask)) *OR* TOPIC: (mpa)) *OR* TOPIC: (delaine)) *OR* TOPIC: (class iii elastics)) *OR* TOPIC: (intermaxillary traction))	158473
	#3	#1 AND #2	1638
	#4	TOPIC: (skeletal class iii malocclusion) *OR* TOPIC: (maxillary hypoplasia) *OR* TOPIC: (angle class iii) *OR* TOPIC: (anterior crossbite) *OR* TOPIC: (reverse occlusion) *OR* TOPIC: (mandibular prognathism) *OR* TOPIC: (mandibular hyperplasia) *OR* TOPIC: (mandibular protrusion) *OR* TOPIC: (maxillary restrusion) *OR* TOPIC: (habsburg jaw) *OR* TOPIC: (hapsburg jaw) *OR* TOPIC: (underbite)	16809

	#5	TOPIC: (randomized controlled trial) *OR* TOPIC: (randomized controlled study) *OR* TOPIC: (controlled clinical trial) *OR* TOPIC: (controlled clinical study) *OR* TOPIC: (controlled study)	5603397
	#6	#5 AND #4 AND #3	49
SCOPUS	#1	(ALL ("orthodontic anchorage") OR ALL ("orthodontic anchor") OR ALL ("orthodontic anchorage procedures") OR ALL ("minicrew") OR ALL ("miniplate") OR ALL ("bone screw") OR ALL ("bone plate") OR ALL ("skeletal anchorage") OR ALL ("skeletal anchor") OR ALL ("bone anchorage") OR ALL ("bone anchor") OR ALL ("mini implant"))	61,427
	#2	(ALL ("orthodontic headgear") OR ALL ("face mask") OR ALL ("extraoral traction appliances") OR ALL ("maxillary protraction") OR ALL ("reverse headgear") OR ALL ("reverse head gear") OR ALL ("protraction head gear") OR ALL ("facemask") OR ALL ("mpa") OR ALL ("delaire") OR ALL ("class iii elastics") OR ALL ("intermaxillary traction"))	303,663

	#3	((ALL ("orthodontic headgear") OR ALL ("face mask") OR ALL ("extraoral traction appliances") OR ALL ("maxillary protraction") OR ALL ("reverse headgear") OR ALL ("reverse head gear") OR ALL ("protraction head gear") OR ALL ("facemask") OR ALL ("mpa") OR ALL ("delaire") OR ALL ("class iii elastics") OR ALL ("intermaxillary traction"))) AND ((ALL ("orthodontic anchorage") OR ALL ("orthodontic anchor") OR ALL ("orthodontic anchorage procedures") OR ALL ("minicrew") OR ALL ("miniplate") OR ALL ("bone screw") OR ALL ("bone plate") OR ALL ("skeletal anchorage") OR ALL ("skeletal anchor") OR ALL ("bone anchorage") OR ALL ("bone anchor") OR ALL ("mini implant")))	1,188
	#4	(ALL ("skeletal class iii malocclusion") OR ALL ("angle class iii") OR ALL ("anterior crossbite") OR ALL ("reverse occlusion") OR ALL ("mandibular prognathism") OR ALL ("mandibular hyperplasia") OR ALL ("mandibular protrusion") OR ALL ("maxillary hypoplasia") OR ALL ("maxillary restrusion") OR ALL ("habsburg jaw") OR ALL ("hapsburg jaw") OR ALL ("underbite"))	10,666

	#5	(ALL ("randomized controlled trial") OR ALL ("controlled clinical trial") OR ALL ("randomized controlled study") OR ALL ("controlled clinical study") OR ALL ("controlled stuty"))	2,150,507
	#6	(((ALL ("orthodontic headgear") OR ALL ("face mask") OR ALL ("extraoral traction appliances") OR ALL ("maxillary protraction") OR ALL ("reverse headgear") OR ALL ("reverse head gear") OR ALL ("protraction head gear") OR ALL ("facemask") OR ALL ("mpa") OR ALL ("delaire") OR ALL ("class iii elastics") OR ALL ("intermaxillary traction"))) AND ((ALL ("orthodontic anchorage") OR ALL ("orthodontic anchor") OR ALL ("orthodontic anchorage procedures") OR ALL ("minicrew") OR ALL ("miniplate") OR ALL ("bone screw") OR ALL ("bone plate") OR ALL ("skeletal anchorage") OR ALL ("skeletal anchor") OR ALL ("bone anchorage") OR ALL ("bone anchor") OR ALL ("mini implant")))) AND ((ALL ("skeletal class iii malocclusion") OR ALL ("angle class iii") OR ALL ("anterior crossbite") OR ALL ("reverse occlusion") OR ALL ("mandibular prognathism") OR ALL ("mandibular hyperplasia") OR ALL ("mandibular protrusion") OR ALL ("maxillary hypoplasia") OR ALL ("maxillary restrusion") OR ALL ("habsburg jaw") OR ALL ("hapsburg jaw") OR ALL ("underbite"))) AND ((ALL ("randomized controlled	80

		trial") OR ALL ("controlled clinical trial") OR ALL ("randomized controlled study") OR ALL ("controlled clinical study") OR ALL ("controlled stuty")))	
CNKI	#1	KY='骨性 III 类+骨性三类' OR FT='骨性三+骨性反+安氏 III+安氏三+前牙反'	504406
	#2	(KY='上颌前牵引' OR FT='前牵引+前方牵引+颌间牵引+III 类牵引') AND (KY='骨支抗' OR FT='微螺钉种植体+微螺钉支抗')	270
	#3	(KY='骨性 III 类+骨性三类' OR FT='骨性三+骨性反+安氏 III+安氏三+前牙反') AND ((KY='上颌前牵引' OR FT='前牵引+前方牵引+颌间牵引+III 类牵引') AND (KY='骨支抗' OR FT='微螺钉种植体+微螺钉支抗'))	94
Wanfang	#1	题名或关键词:(骨性 III 类)+全部:(骨性三类+骨性三+骨性反+安氏 III+安氏三+前牙反)	29163
	#2	题名或关键词:(上颌前牵引)+全部:(前牵引+前方牵引+颌间牵引+III 类牵引)	61801
	#3	题名或关键词:(骨支抗)+全部:(微螺钉种植体+微螺钉支抗)	829
	#4	(题名或关键词:(骨性 III 类)+全部:(骨性三类+骨性三+骨性反+安氏 III+安氏三+前牙反)) AND ((题名或关键词:(上颌前牵引)+全部:(前牵引+前方牵引+颌间牵引+III 类牵引)) AND (题名或关键词:(骨支抗)+全部:(微螺钉种植体+微螺钉支抗)))	21

Total	374

Appendix 2 Description of the interventions

1. Control group

Patients in this group were untreated class III malocclusion patients.

2. Tooth-anchored group

Interventions in this group were concluded as FM. The facemask was protracted with the boned or banded intraoral appliance.

3. Bone-anchored group

Interventions that only used bone-anchorage, such as mini plates or mini-screws, were classified as a bone-anchored group, including bone-anchorage with facemask appliance (BAFM) and bone-anchorage with intermaxillary protraction (BAIP).

BAFM: Mini plates or mini-screws were placed on both sides of the lateral nasal wall (Figure 1), the posterior areas, or the zygomatic buttress areas of the maxilla (Figure 2). The protraction sites were all at the bilateral canine regions. The bone anchorages were protracted with the facemask by elastic.

BAIP: Two mini-screws were placed on both sides of the posterior areas or the zygomatic areas in the maxilla, and another two mini-screws were placed on bilateral canine regions of the mandible. The mini-screws were protracted with class III intermaxillary protraction (Figure 3).

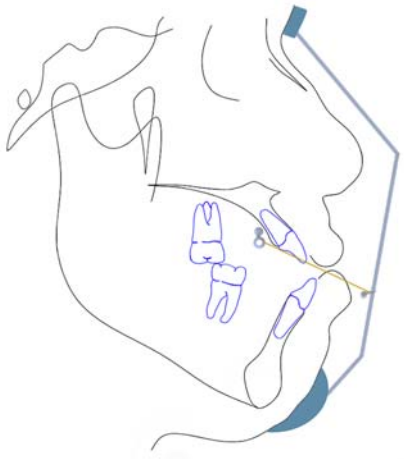


Figure 1

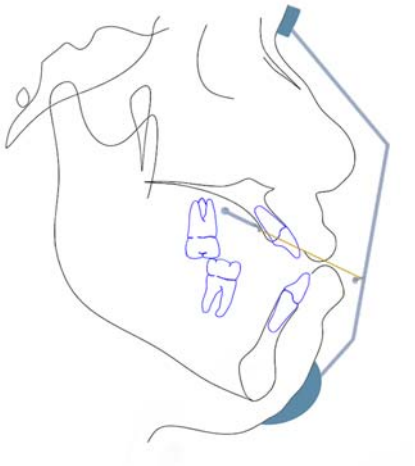


Figure 2

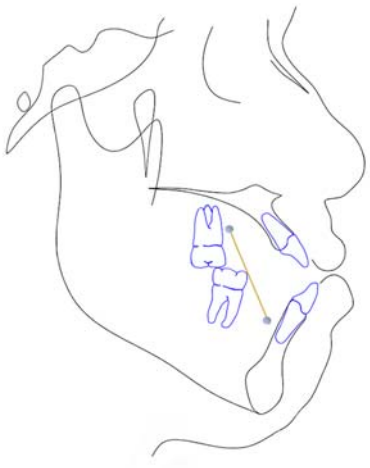


Figure 3

4. Mixed-anchored group

Interventions that combined bone-anchorage and bond or bands were classified as a mixed-anchored group, including mixed-anchorage with a facemask (MAFM) and mixed-anchorage with intermaxillary protraction (MAIP).

MAFM: Interventions in this group included two types:

1) Hybrid Hyrax expansion appliance protracted with a facemask. Hybrid Hyrax expansion appliance combined two bands on the bilateral first molars with two mini screws implanted in the palate. The protraction sites were at the bilateral canine regions.

2) A lingual arch attached to a mini screw protracted with a facemask. This kind of intervention was applied by Seiryu et al. [11]. They set a lingual arch on the maxilla with two bands on bilateral first molars. A mini screw was inserted into the palate. The mini screw was combined with the lingual arch by wire and resin. A facemask was protracted with the intraoral device through the solder hooks on the arch. The protraction sites were at the bilateral canine regions.

MAIP: Patients in this group were treated with class III elastics.

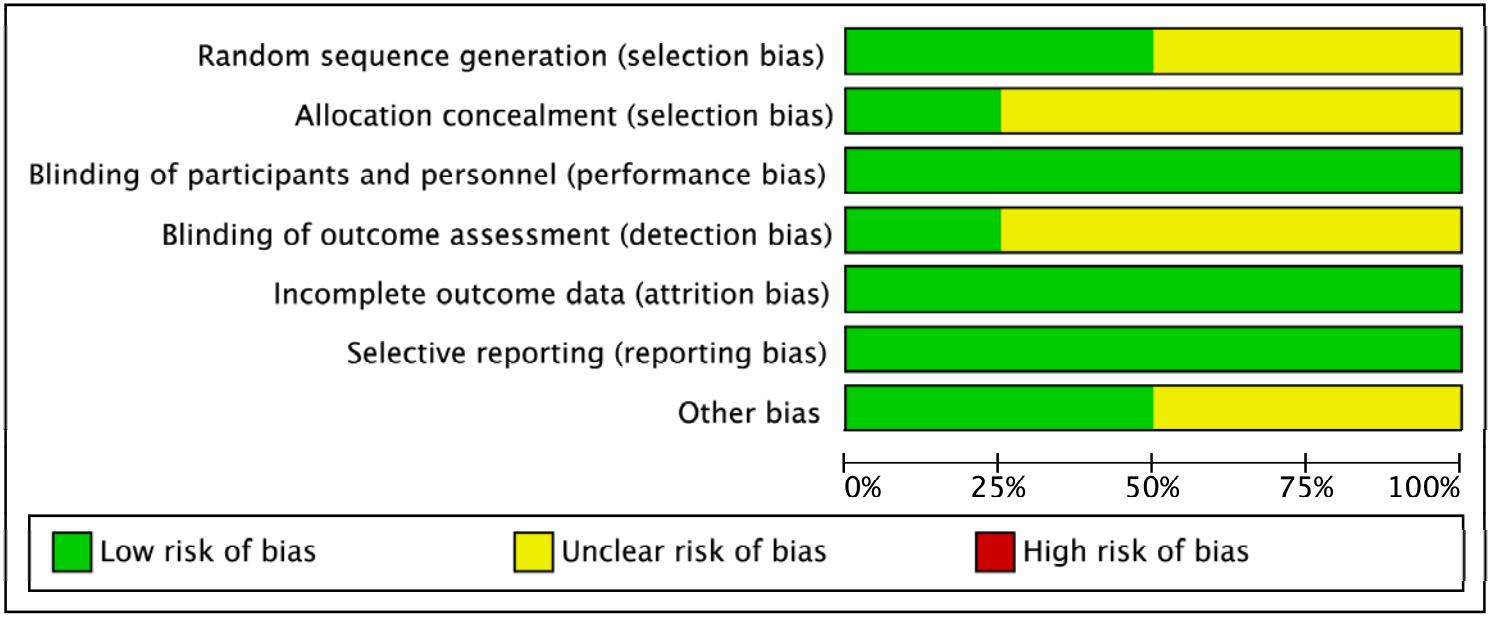
1) In Sar et al.' research[23], two mini plates were placed in the symphyseal region. The elastic was between the miniplate and the bonded rapid maxillary expansion appliance.

2) In Willmann et al.'s research[24], the mentoplate was inserted in the mandibular anterior region. The class III elastic was between the Hybrid Hyrax expansion appliance and the mentoplate.

Appendix 3 Quality assessment of RCTs and CCTs

Study	Selection	Comparability	Exposure	Total	Assessment
Aglarci 2016	4	1	3	8	Good
Erdal 2017	4	0	3	7	Satisfactory
De 2019	4	2	3	9	Good
Koh 2014	4	2	3	9	Good
Lee 2012	4	1	3	8	Good
Lee 2019	4	2	3	9	Good
Ngan 2015	4	0	3	7	Satisfactory
Sar 2014	4	1	3	8	Good
Willmann 2018	4	2	3	9	Good
Cha 2011	4	0	3	7	Satisfactory
Eid 2016	4	1	3	8	Good
Tripathi 2016	4	0	3	7	Satisfactory
Sar 2011	4	1	3	8	Good
Nienkemper 2015	4	2	3	9	Good

Quality Assessment of CCTs



Quality Assessment of RCTs

Risk of bias graph

Quality Assessment of RCTs

Risk of bias summary

Appendix 4 Pair-wised results of network meta-analysis for outcomes

SNA					
BAFM					
0.19 (-0.59,0.97)	BAIP				
2.33 (1.88,2.87)	2.14 (1.37,2.98)	CONTROL			
0.72 (0.34,1.11)	0.53 (-0.18,1.25)	-1.61 (-2.16,-1.14)	FM		
-0.20 (-0.83,0.47)	-0.38 (-1.27,0.54)	-2.53 (-3.20,-1.88)	-0.91 (-1.48,-0.31)	MAFM	
-0.08 (-0.73,0.62)	-0.27 (-1.20,0.71)	-2.41 (-3.13,-1.73)	-0.80 (-1.45,-0.11)	0.12 (-0.61,0.85)	MAIP
SNB					
BAFM					
-0.13 (-0.99,0.80)	BAIP				

-1.96 (-2.68,-1.22)	-1.83 (-2.71,-1.01)	CONTROL			
0.23 (-0.29,0.78)	0.36 (-0.54,1.22)	2.19 (1.44,2.95)	FM		
-0.05 (-1.01,0.93)	0.08 (-1.10,1.22)	1.91 (0.91,2.91)	-0.28 (-1.15,0.58)	MAFM	
-0.87 (-2.18,0.54)	-0.74 (-2.23,0.79)	1.09 (-0.28,2.54)	-1.10 (-2.34,0.21)	-0.82 (-1.96,0.41)	MAIP

ANB

BAFM					
-1.17 (-2.46,0.26)	BAIP				
2.86 (2.02,3.76)	4.03 (2.62,5.35)	CONTROL			
0.87 (-0.16,1.97)	2.03 (0.67,3.34)	-1.99 (-3.14,-0.83)	FM		
0.45 (-1.15,2.08)	1.62 (-0.35,3.46)	-2.40 (-4.08,-0.78)	-0.41 (-1.91,1.02)	MAFM	
-0.34 (-1.74,1.11)	0.84 (-1.04,2.61)	-3.20 (-4.64,-1.75)	-1.20 (-2.75,0.32)	-0.79 (-2.29,0.73)	MAIP

Wits

BAFM					
-0.17 (-2.43,2.20)	BAIP				
6.56 (4.78,8.33)	6.72 (4.25,9.09)	CONTROL			
0.02 (-1.61,1.58)	0.18 (-2.11,2.30)	-6.54 (-8.52,-4.62)	FM		
1.01 (-1.83,3.79)	1.18 (-2.13,4.32)	-5.55 (-8.21,-2.94)	0.99 (-1.63,3.64)	MAFM	
1.68 (-2.65,5.93)	1.85 (-2.78,6.36)	-4.87 (-9.09,-0.71)	1.67 (-2.51,5.86)	0.67 (-2.60,3.92)	MAIP

SNOr

BAFM					
-0.51 (-2.63,1.62)	BAIP				
2.48 (0.43,4.54)	2.99 (0.91,5.09)	CONTROL			
1.22 (0.06,2.29)	1.72 (-0.71,4.08)	-1.27 (-3.62,1.02)	FM		

SN/MP

BAFM					
2.39 (0.46,4.14)	BAIP				
2.17 (0.95,3.38)	-0.22 (-1.87,1.57)	CONTROL			
-1.16 (-2.29,0.04)	-3.55 (-5.48,-1.38)	-3.33 (-4.77,-1.80)	FM		
-0.13 (-1.98,1.84)	-2.52 (-4.91,0.18)	-2.30 (-4.30,-0.15)	1.03 (-0.57,2.69)	MAFM	
-0.98 (-2.64,0.75)	-3.37 (-5.59,-0.89)	-3.15 (-4.91,-1.29)	0.18 (-1.49,1.84)	-0.84 (-2.80,1.04)	MAIP
ANS-Me					
BAFM					
-2.77 (-7.34,1.77)	BAIP				
2.21 (0.07,4.35)	4.98 (0.16,9.84)	CONTROL			
-2.61 (-4.80,-0.44)	0.16 (-3.83,4.19)	-4.82 (-7.54,-2.12)	FM		
2.31 (-2.22,6.83)	5.08 (-1.17,11.36)	0.10 (-3.91,4.11)	4.91 (0.11,9.76)	MAFM	
-1.76 (-5.26,1.77)	1.01 (-4.63,6.72)	-3.97 (-7.48,-0.44)	0.85 (-3.16,4.90)	-4.06 (-9.41,1.27)	MAIP
Overjet					

BAFM					
-0.52 (-1.96,0.90)	BAIP				
7.22 (6.24,8.13)	7.74 (6.23,9.20)	CONTROL			
-0.30 (-1.24,0.64)	0.22 (-1.12,1.58)	-7.52 (-8.62,-6.36)	FM		
2.85 (1.01,4.72)	3.37 (1.27,5.53)	-4.37 (-6.12,-2.51)	3.15 (1.40,4.94)	MAFM	
0.79 (-1.01,2.58)	1.31 (-0.89,3.52)	-6.43 (-8.17,-4.62)	1.09 (-0.87,3.04)	-2.07 (-4.55,0.38)	MAIP

Overbite

BAFM					
-0.30 (-1.37,0.85)	BAIP				
-1.35 (-2.16,-0.53)	-1.05 (-2.23,0.06)	CONTROL			
0.01 (-0.76,0.88)	0.31 (-0.71,1.37)	1.36 (0.47,2.35)	FM		
-1.09 (-2.65,0.49)	-0.80 (-2.54,0.93)	0.26 (-1.21,1.75)	-1.11 (-2.65,0.39)	MAFM	
3.35 (1.55,5.07)	3.65 (1.58,5.59)	4.70 (2.93,6.40)	3.34 (1.38,5.14)	4.44 (2.15,6.65)	MAIP

U1/PP

BAFM					
-1.11 (-4.59,1.66)	BAIP				
-0.33 (-2.65,1.93)	0.79 (-1.73,3.94)	CONTROL			
-3.27 (-6.95,-0.10)	-2.15 (-5.49,1.32)	-2.95 (-6.43,0.08)	FM		
-0.50 (-5.37,4.41)	0.66 (-4.33,6.17)	-0.16 (-4.67,4.39)	2.80 (-2.34,8.35)	MAFM	
-2.87 (-6.56,0.87)	-1.74 (-5.61,2.85)	-2.55 (-5.97,1.04)	0.42 (-3.56,4.87)	-2.37 (-6.83,2.15)	MAIP

IMPA

BAFM					
-4.54 (-7.11,-2.28)	BAIP				
-3.87 (-5.58,-2.21)	0.68 (-1.41,3.00)	CONTROL			
1.08 (-0.39,2.37)	5.65 (3.00,8.30)	4.96 (2.92,6.81)	FM		
-1.86 (-4.76,1.02)	2.71 (-0.66,6.27)	2.01 (-0.78,4.81)	-2.94 (-5.69,-0.05)	MAFM	

-5.33 (-9.36,-1.41)	-0.76 (-5.20,3.72)	-1.46 (-5.56,2.53)	-6.40 (-10.23,-2.54)	-3.47 (-7.09,0.07)	MAIP

Appendix 5 Funnel figures

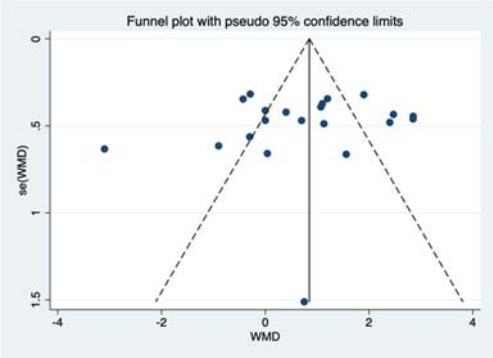


Figure 4 SNA

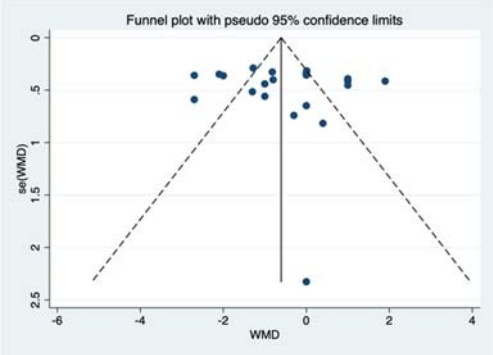


Figure 5 SNB

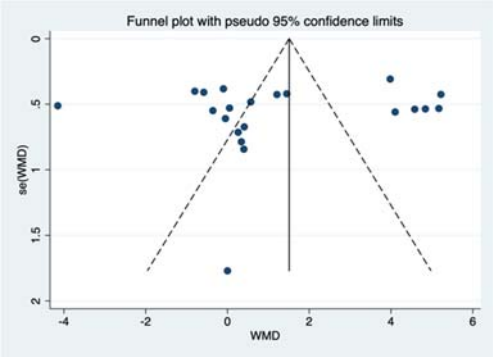


Figure 6 ANB

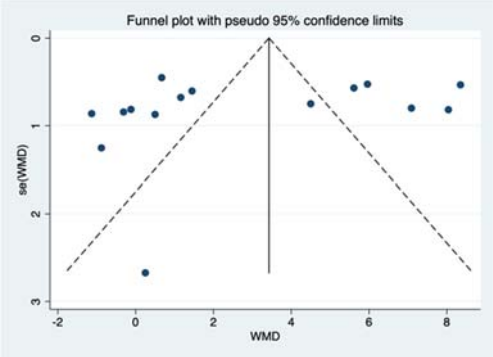


Figure 7 Wits

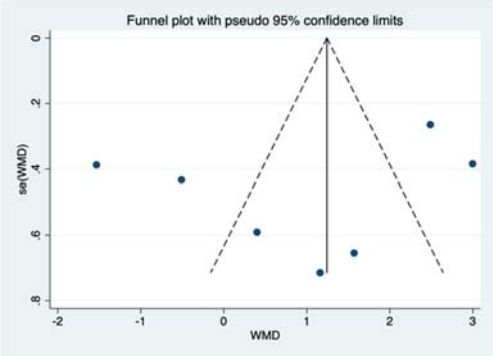


Figure 8 SNOr

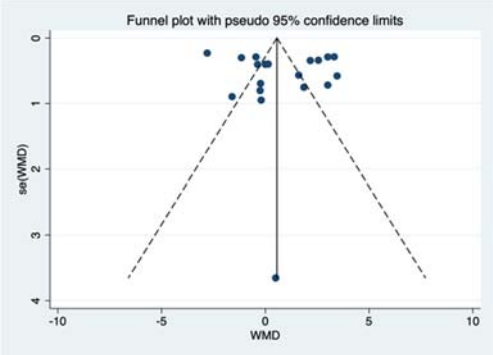


Figure 9 SN/MP

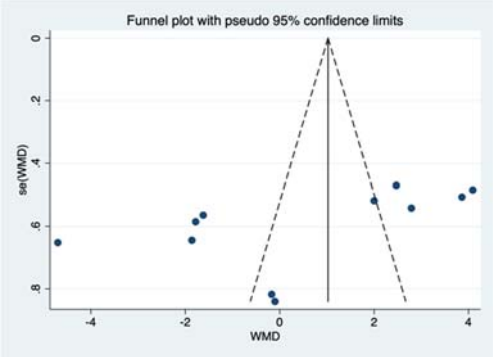


Figure 10 ANS-Me

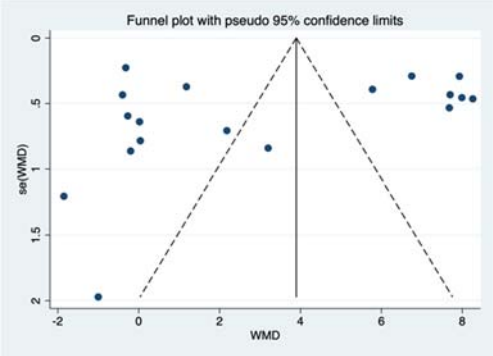


Figure 11 Overjet

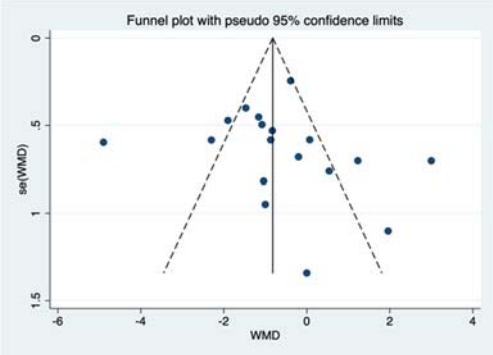


Figure 12 Overbite

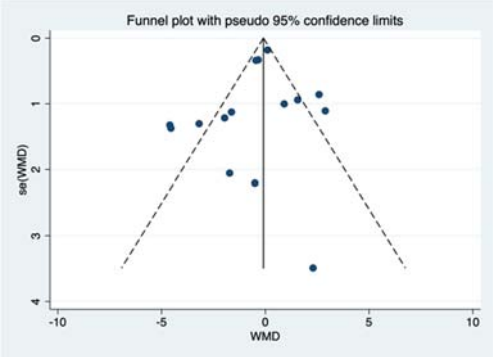


Figure 13 U1/PP

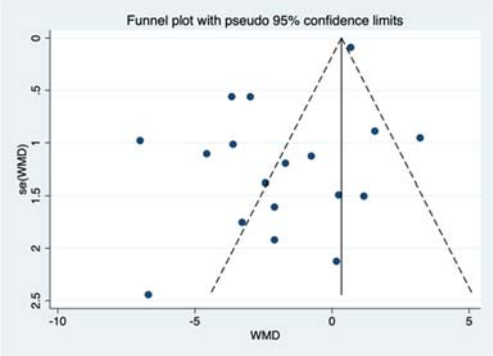


Figure 14 IMPA