STABILITY OF SKELETAL CLASS III MALOCCLUSION AFTER ORTHOGNATHIC SURGERY AND ORTHODONTIC TREATMENT: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: Relapse is one of the major concerns in the correction of skeletal class III malocclusion
Objective: The purpose of this systemic review was to evaluate the degree of relapse on skeletal class III patients who received bimaxillary surgery or mandibular setback with orthodontic treatment.
Data Sources: A search of the literature was performed in the databases of PubMed, Google Scholar Beta, Scopus, Web of Science, and the Cochrane Library.
Study Selection: Out of the 165 articles identified, 73 studies were obtained, once duplicated articles were excluded. Then, 40 other records were excluded due to titles and abstracts, and 20 were removed for not fulfilling exclusion/inclusion criteria. 11 studies met the final inclusion criteria. Some cephalometric data during T1–T2–T3 were measured.
Data Extraction: SNA did not have any significant changes within less than 2 years but it increased significantly after 2 years. SNB did not have any significant changes in more than 2 years' follow-up, while it rose significantly in less than 2 years. Overjet decreased significantly after 2 years but not earlier than this duration. Overbite intensified significantly in more than 2 years and not earlier.
Data Synthesis: SNA and overbite increased significantly after 2 years. SNB increased significantly before 2 years and did not have any changes after it. Overjet was significantly reduced after 2 years.
Keywords: Class III; Skeletal and Dental Changes; Stability; Bimaxillary Surgery or mandibular setback; Systematic review and meta-analysis

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1. Introduction

Moderate to severe skeletal class III patients often require a combined orthodontic and surgical approach for treatment. It has been reported that skeletal class III malocclusion is the most frequent deformity corrected by combined orthognathic surgery and orthodontic treatment.[1-4] However, bimaxillary surgery has gradually become more popular to correct class III malocclusion. [5-7] It has been estimated that 20% to 25% of all Class III cases have true mandibular prognathism suggesting that at least 75% of all class III malocclusions have some degree of maxillary retrusion. Given this scenario, the surgical treatment has been regarded as the best approach to achieve the best results in adult cases.[8]

Post-surgical relapse is one of the major concerns in the correction of skeletal class III malocclusion. It has been shown that there is a greater tendency for relapse after bimaxillary osteotomy.[9] Similarly, LaBanc et al. [10] reported that due to increased incidence of relapse, bimaxillary surgery should only

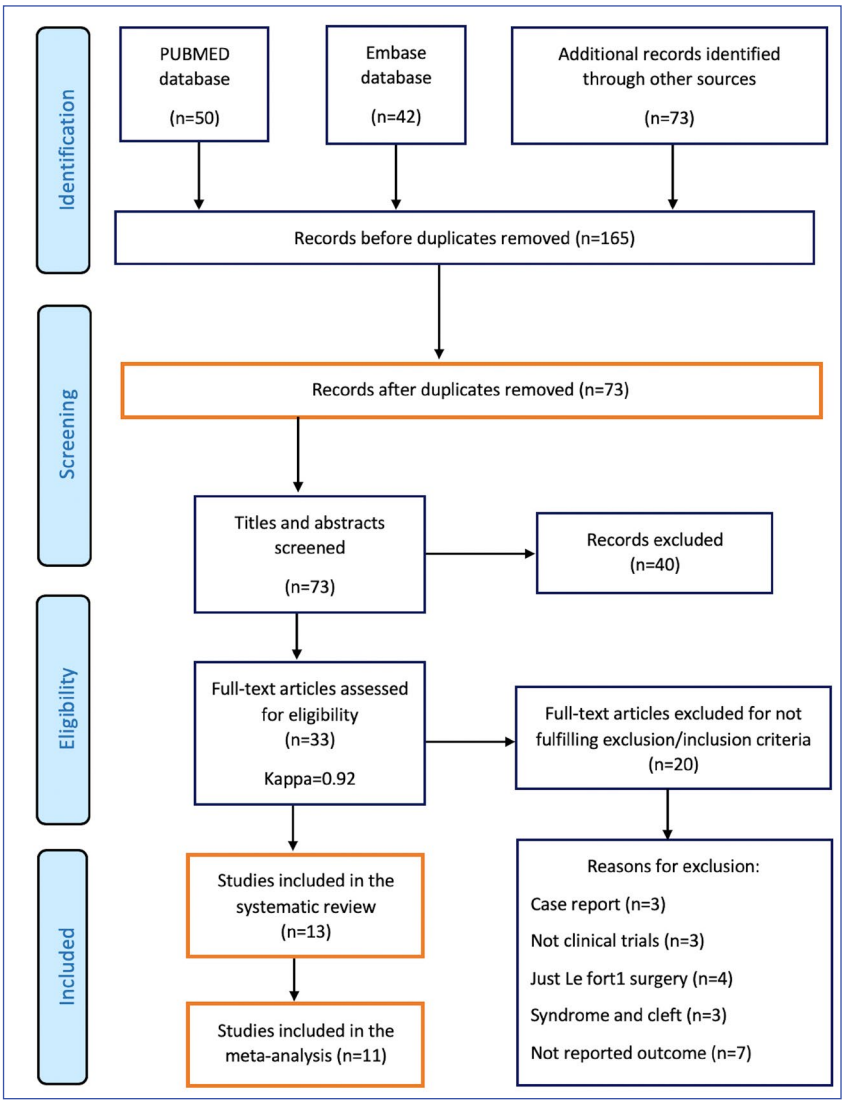

Figure 1. PRISMA flowchart of article retrieval.

be performed for specific indications; for example two-jaw surgery has greater relapse than single-jaw surgery. On the contrary, Proffit et al. [11] found that better stability and predictable results can be obtained after two-jaw surgery.

Immediate relapse can be identified after surgery which may occur due to intraoperative error such as imprecise planning, inaccurate osteosynthesis, or failure to fix the joint. On the other hand, late relapse can be detected once a considerable period has elapsed since the day of the surgical procedure. Late relapse may occur due to unstable occlusal relationships, growth spurts, absence of myofunctional adaptation, or persistent tongue or orofacial muscle habits.[12] A study[5] revealed that the rate of short-term relapse of bilateral sagittal split osteotomy setback surgery is 9.9%-62.1%, and long-term relapse is between 14.9% and 28.0%, at point B. To the best of our knowledge, there has been no meta-analysis evaluating the stability of skeletal changes after a combined orthodontic and surgical procedure for treatment of skeletal Class III patients in short- and long-term follow ups. The question is: "How much of the treatment effects remains stable by the end of follow-up?"

Objectives: The aim of this study was a meta-analysis of the literature on the stability of skeletal class III malocclusion. Patients often require a combined orthodontic and surgical approach after bimaxillary surgery. This meta-analysis was undertaken to explore the parameters related to the skeletal stability in surgical correction of skeletal Class III malocclusion.

2. Materials and methods

2.1. Protocol and registration

This systematic review was based on a specific protocol developed and piloted following the guidelines outlined in the PRISMA-P statement. [13] Furthermore, the procedure and reporting followed the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions[14] and the PRISMA statement,[15] respectively

2.2. Information sources, search strategy, and study selection

A literature search was performed using PubMed, Google Scholar Beta, Scopus, Web of Science, and the Cochrane Library to identify articles reporting combined orthodontic and surgical approach

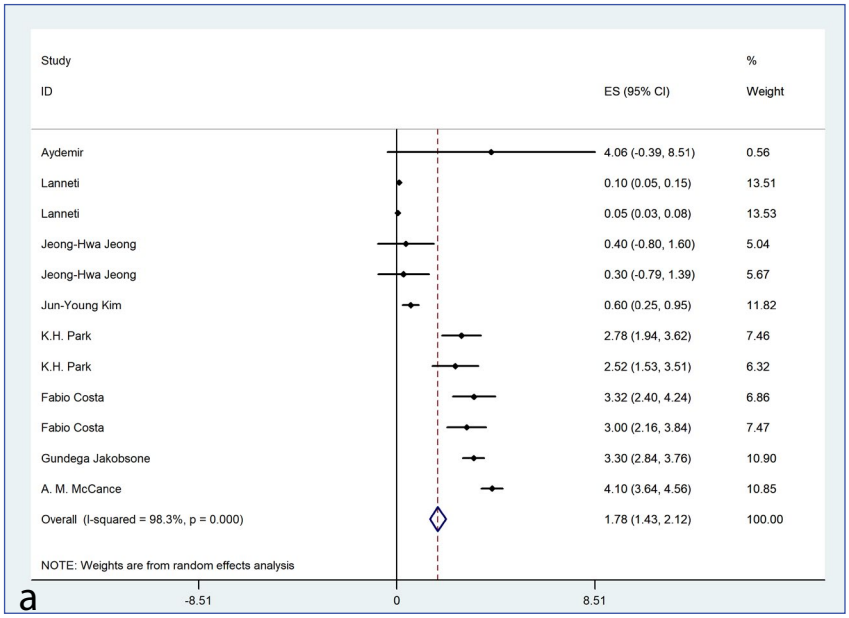

Figure 2a. Before surgery T1 - After surgery T2, (T1-T2) SNA.

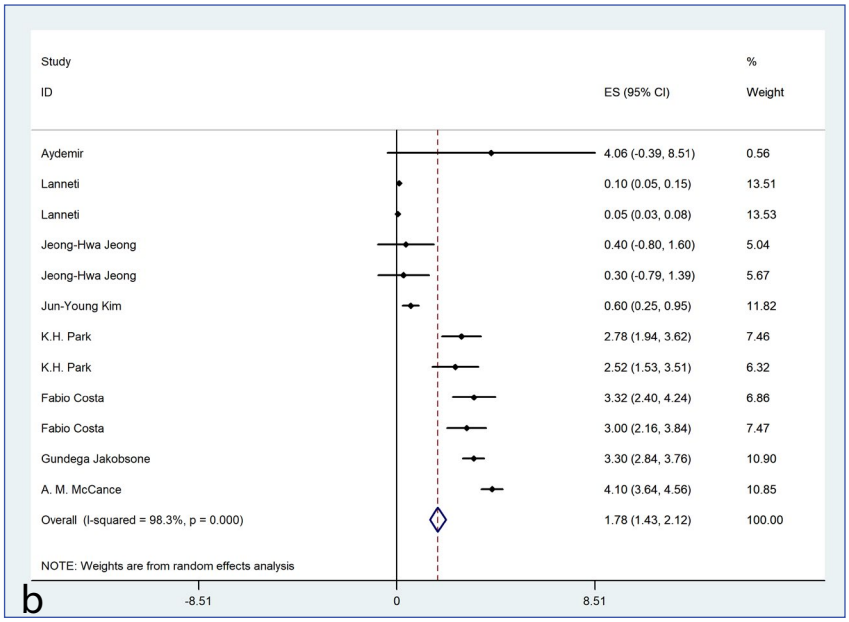

Figure 2b. After surgery T2 - Last follow-up T3, (T2-T3) SNA

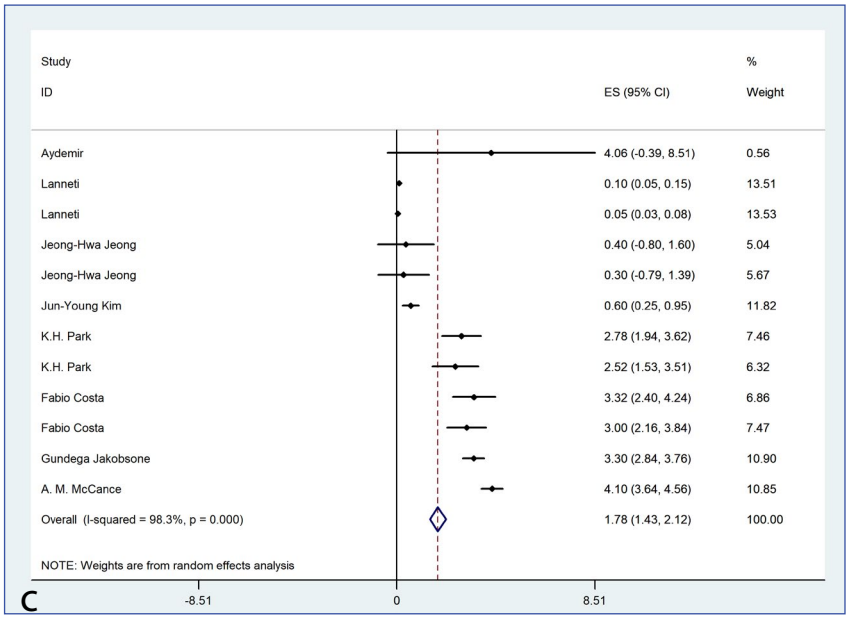

Figure 2c. Subgroup analysis according to the follow-up period (SNA).

1. Less than 2 years. ; 2. More than 2 years.

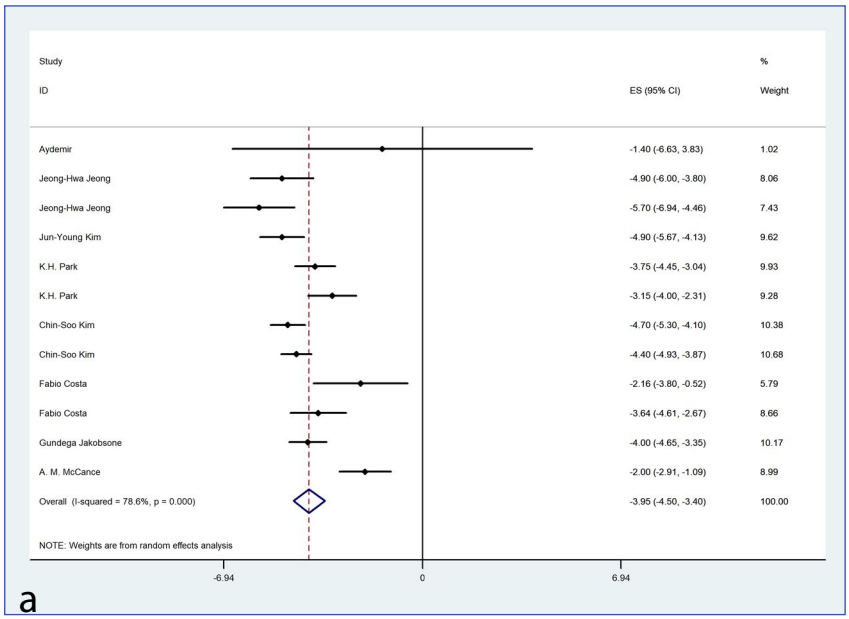

Figure 3a. Before surgery T1 - After surgery T2, (T1-T2) SNB.

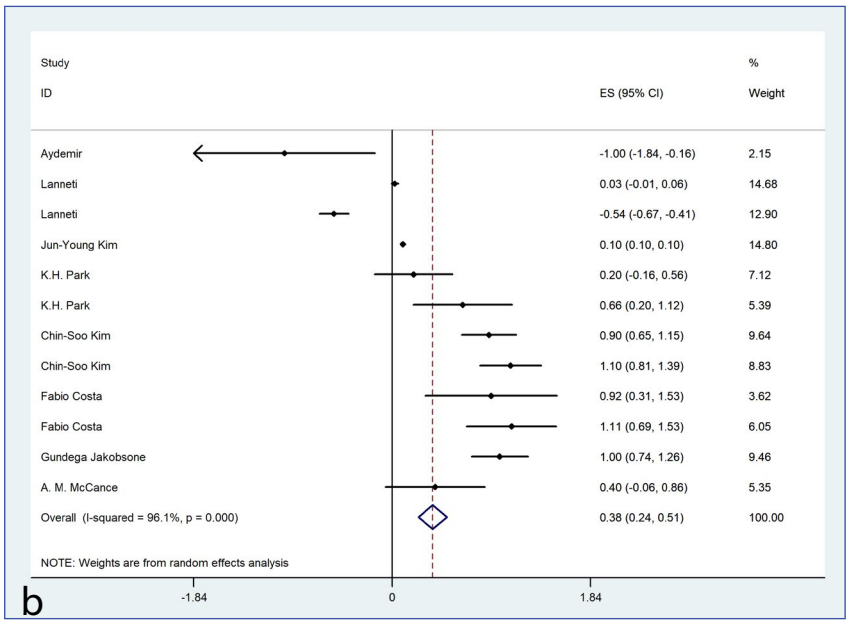

Figure 3b. After surgery T2 - Last follow-up T3, (T2-T3) SNB.

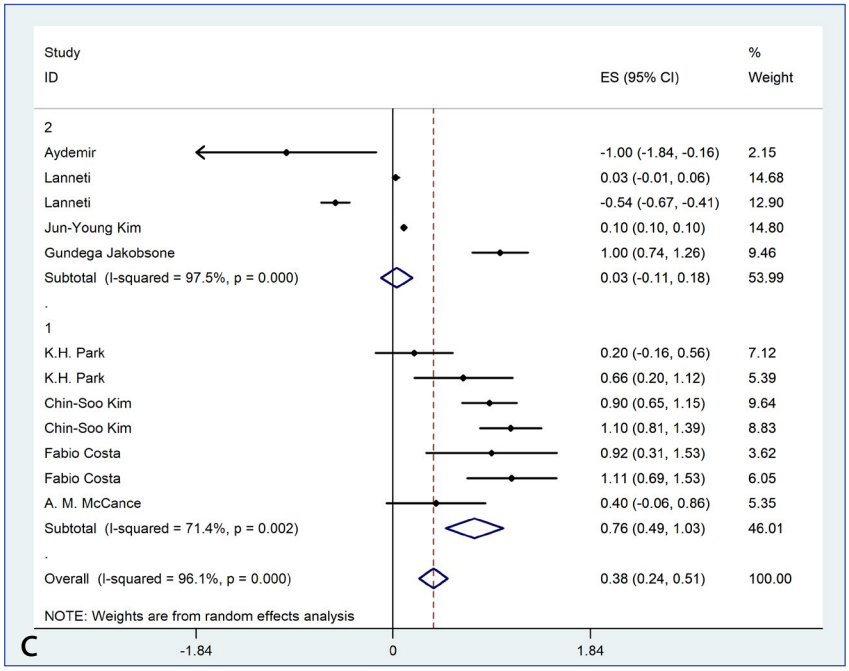

Figure 3c. Subgroup analysis according to the follow-up period (SNB).

1. Less than 2 years. ; 2. More than 2 years.

for treatment of skeletal class III malocclusion in non-growing patients. The search process was conducted independently by two coauthors (AJ and AD) for articles published up to December 2018. All titles and abstracts were evaluated, and duplicate studies were removed.

2.3. Eligibility criteria

The inclusion and exclusion criteria were established prior to the search according to Table 1. Each keyword was carefully selected and revised for each database. All keywords used in the search are detailed in Table 2. This systematic review and meta-analysis was conducted based on the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines[16]. Title-abstract-full text of each article was checked independently by two coauthors based on the PRISMA chart.

2.4. Data collection and data items

Two authors (AJ and AD) used pre-defined electronic sheets to extract study characteristics independently. Three time points were defined: T1 (before surgery), T2 (after surgery), and T3 (the end of the follow-up). The findings were obtained on the following items:

Name of first author, year of publication, country, number and mean age of patients, gender, type of surgery (Mandibular setback including BSSO or vertical osteotomy) or (Bimaxillary surgery including Lefort 1 + BSSO or Lefort 1 + vertical), type of fixation including Rigid Internal Fixation (RIF) or Maxillomandibular Fixation (MMF), follow-up after surgery until 2 years, follow-up after surgery until 5 years, SNA, SNB, ANB, overjet, overbite, incisor mandibular plane angle (IMPA), upper incisor to SN (U1/SN) angle, during T1–T2 (surgical effects), T2–T3 (posttreatment changes) were recorded.

In order to identify the correlation between relapse and cephalometric landmarks, meta-analyses were conducted between cephalometric landmarks and different variables such as type of surgery (mandibular setback including BSSO or vertical osteotomy) or (bimaxillary surgery including Lefort 1 + BSSO or Lefort 1 + vertical), type of fixation including Rigid Internal Fixation (RIF) or Maxillomandibular Fixation (MMF), follow-up after surgery within 2 years, follow-up after surgery within 5years.

The cutoff value of less than 2 years was chosen to separate short-term from long-term studies.

2.5. Statistical analysis

All statistical tests were conducted using the STATA 14 (StataCorp LP, College Station, USA). The effects of bimaxillary surgery or mandibular setback on SNA, SNB, ANB, overjet, overbite, incisor mandibular plane angle (IMPA) and upper incisor to SN (U1/SN) angle, before and after surgery as well as the last follow-up were measured by weighted mean difference (WMD) and the 95% confidence intervals (CI). The standard error (SE) of the mean difference (MD) for non-reported studies was calculated by the following formula: SD^2 baseline + SD^2 final – (2 R* SD baseline + SD final) and SD=SE*sq(n). Heterogeneity across studies was assessed using the I-squared and the alpha of 0.05 for statistical significance.

The subgroup analysis was based on the time of follow-up to identify the source of heterogeneities. To identify the source of clinical heterogeneity, susceptible variables including treatment plan, gender, country, treatment time, type of surgery, type of fixation, and follow-up time were introduced into a meta-regression model. WMD with 95% CI was calculated for all variables.

The publication bias was determined using Begg tests. The p-value of 0.05 was regarded for statistical significance.

The changes in seven variables (SNA, SNB, ANB, IMPA, overjet, U1/SN, and L1/MP) during three time periods [Before surgery (T1), after surgery (T2) and last follow-up (T3)] were compared between the studies. The summarized data of included studies and cephalometric measurements of the included studies are seen in Tables 3 and 4 respectively. The results of the statistical analysis for heterogeneity and the funnel plots are displayed in Figures 2, 3, 4, 5, 6, 7, and 8.

3. Results

3.1. Study selection and characteristics

Of the 165 records resulting from the search strategies, 73 studies were obtained once duplicated articles were excluded. Then, 40 papers were removed because of their titles and abstracts. In addition, 20 more were further excluded for not meeting the exclusion/inclusion criteria. Ultimately, 13 papers met the final selected criteria and were selected to conduct the systematic review and meta-analysis. The manual search did not yield any additional material. In case of disagreement, the authors discussed the controversy until an agreement was reached.

Of the 13 studies, 2 of them did not provide us with enough data for the meta-analysis and were excluded from the study. Performing meta-analysis was only feasible for 11 studies, and these studies were included in our study. These studies include non-growing patients with Class III malocclusion with Follow-up of 6 months or longer. The level of inter-examiner agreement of data extraction was measured using kappa statistics. The level of agreement between the two examiners was assessed using the Cohen kappa scores. The kappa score for study selection was 0.978, indicating an excellent level of agreement. The PRISMA flow diagram of study selection is outlined in Fig. 1

Before surgery T1– After surgery T2, (T1–T2) Figures 2a, 3a, 4a, 5a, 6a, 7a, and 8a

Short-term treatment effects included significant increase in SNA (WMD 1.78, 95%CI:1.42, 2.12),

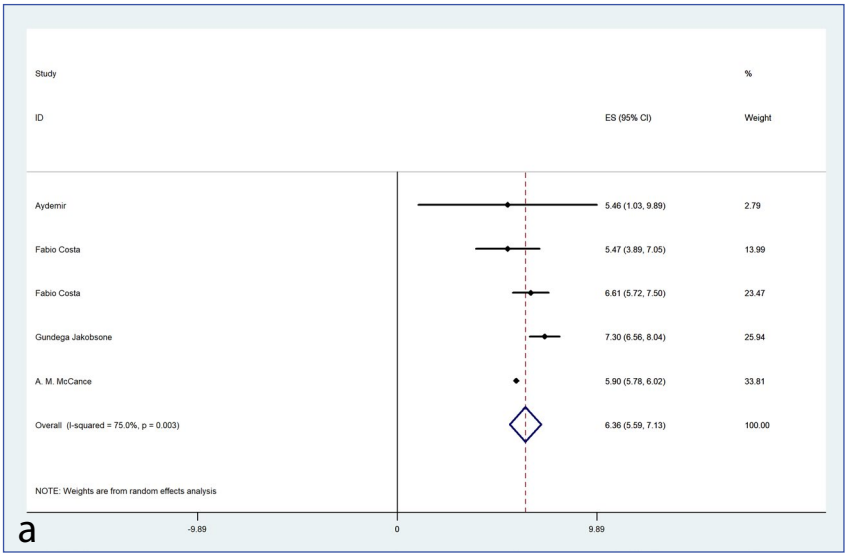

Figure 4a. Before surgery T1 - After surgery T2, (T1-T2) ANB.

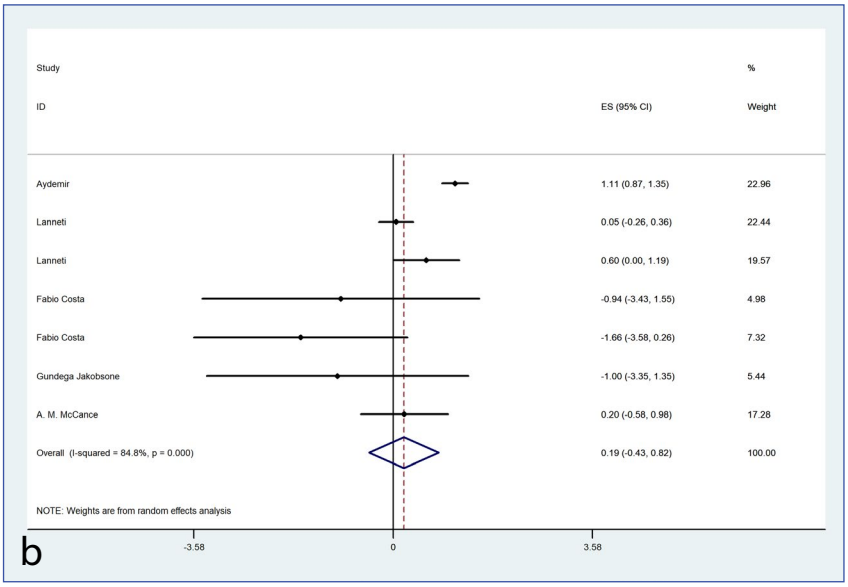

Figure 4b. After surgery T2 - Last follow-up T3, (T2-T3) ANB.

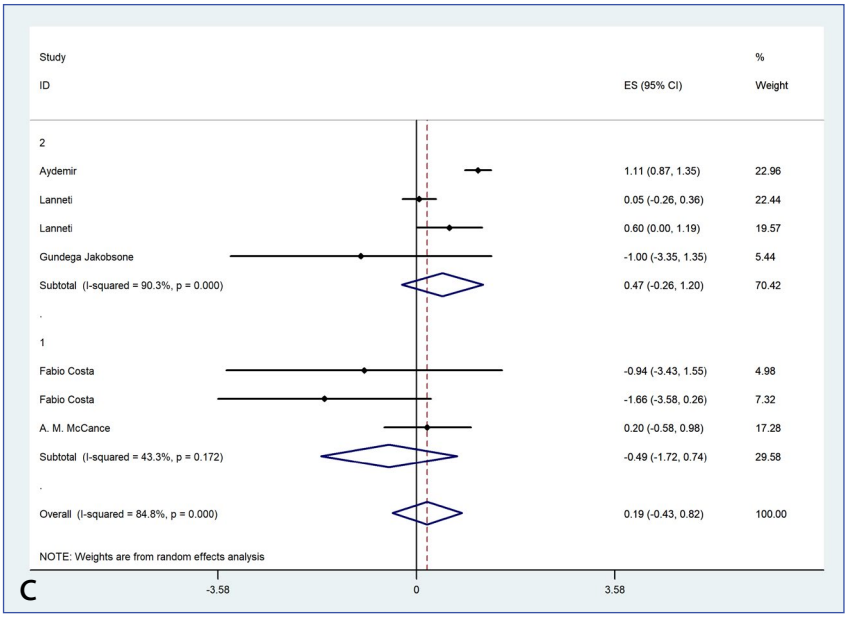

Figure 4c. Subgroup analysis according to the follow-up period (ANB).

1. Less than 2 years. ; 2. More than 2 years.

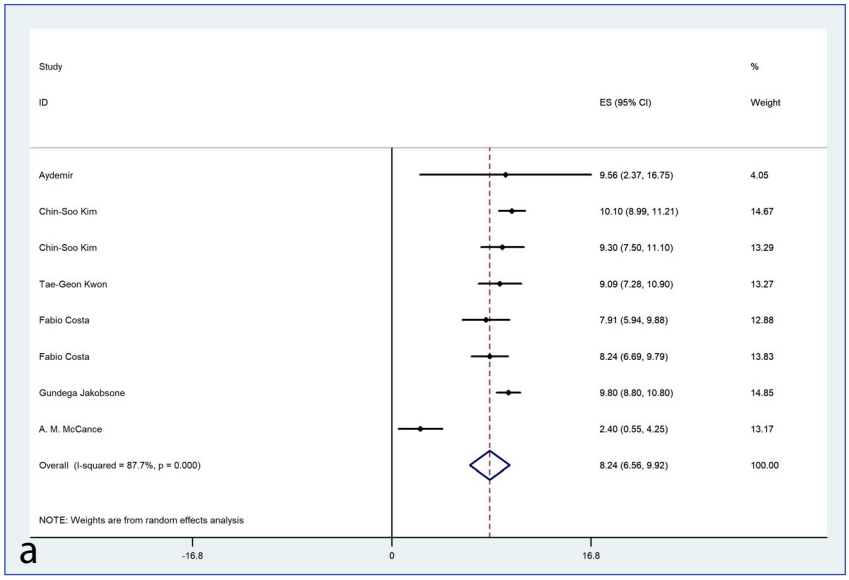

Figure 5a. Before surgery T1 - After surgery T2, (T1-T2) Overjet.

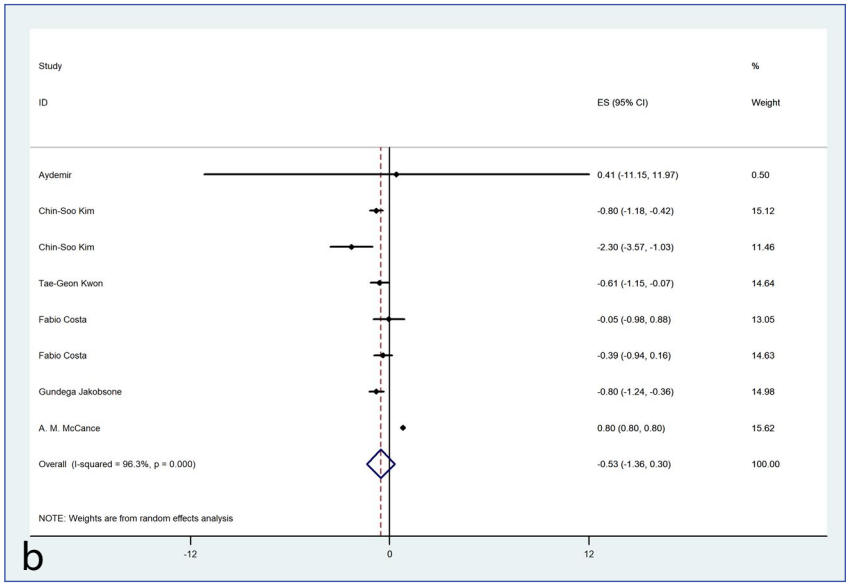

Figure 5b. After surgery T2 - Last follow-up T3, (T2-T3) Overjet.

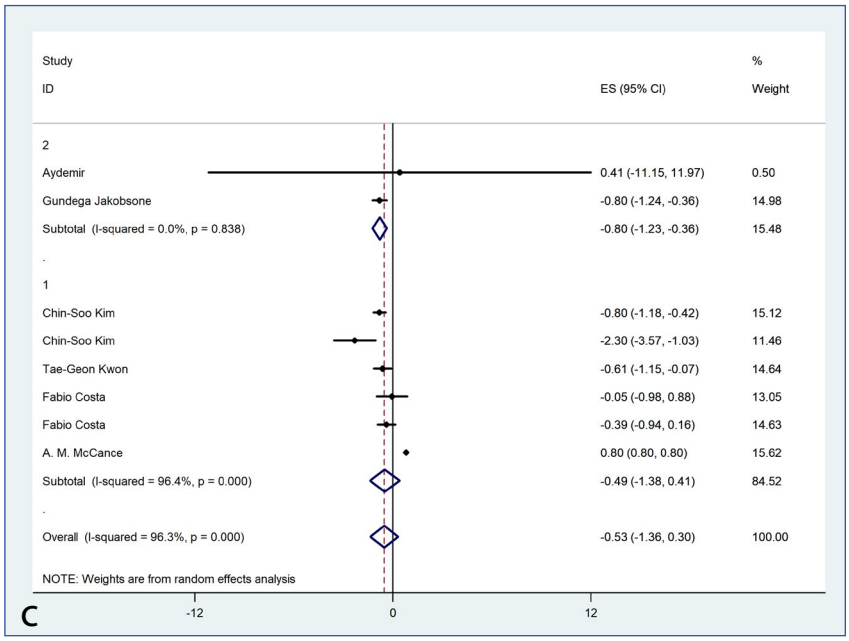

Figure 5c. Subgroup analysis according to the follow-up period (Overjet).

1. Less than 2 years. ; 2. More than 2 years.

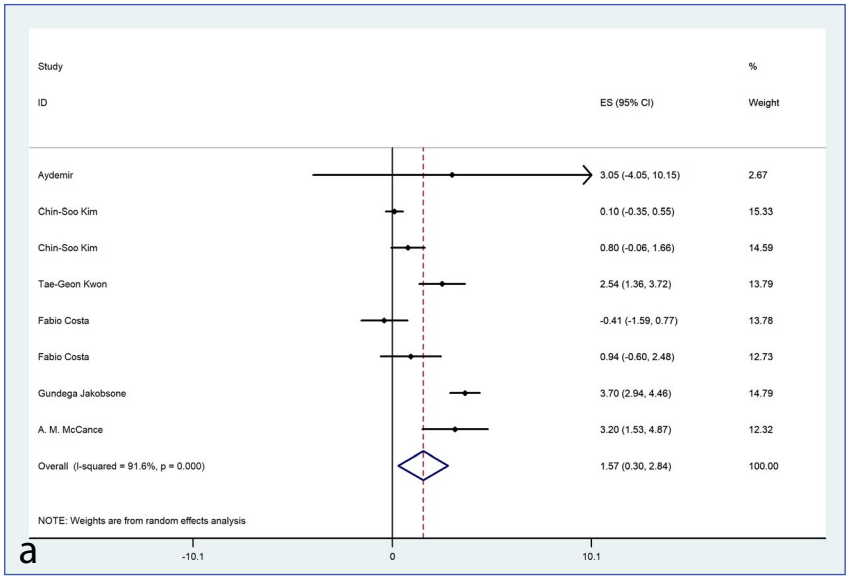

Figure 6a. Before surgery T1 - After surgery T2, (T1-T2) Overbite.

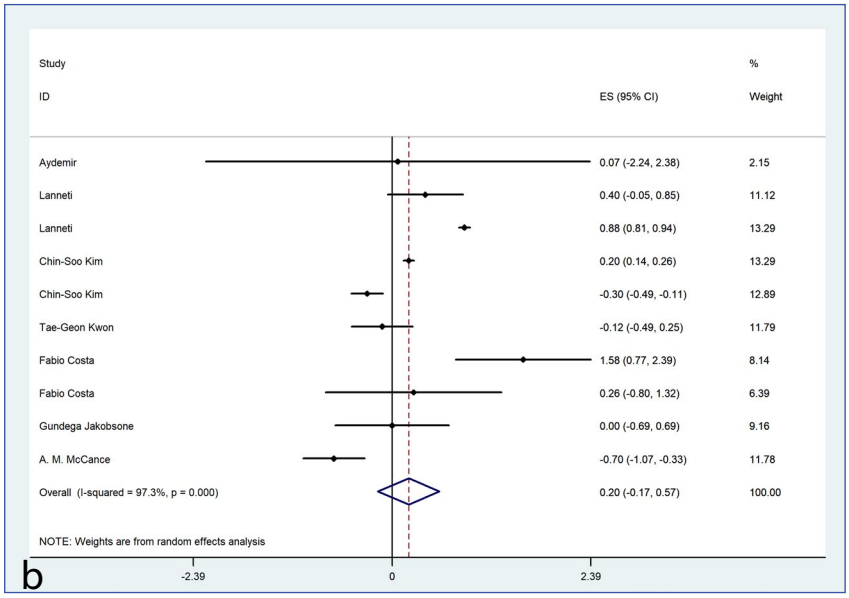

Figure 6b. After surgery T2 - Last fallow-up T3, (T2-T3) Overbite.

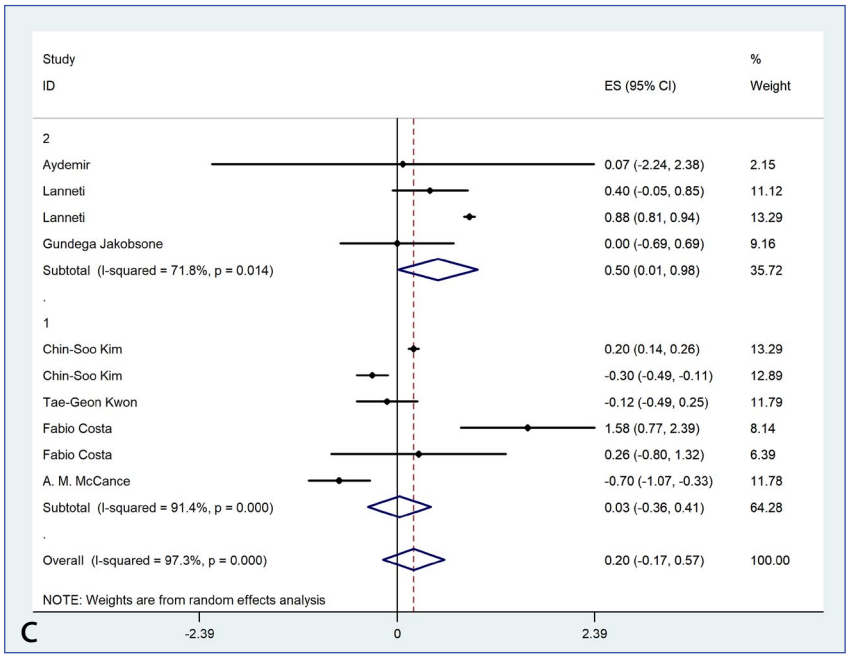

Figure 6c. Subgroup analysis according to the follow-up period (Overbite).

1. Less than 2 years. ; 2. More than 2 years.

Table 1. Eligibility criteria used for the study selection.

Category	Inclusion criteria	Exclusion criteria
Study design	Randomized controlled trials Controlled clinical trials Cohort studies Experimental studies, prospective and retrospective studies comparing at least two surgical treatment strategies Articles written in the English language	Case reports Commentaries Systematic reviews or meta-analyses descriptive studies, opinion articles, or abstracts
Participants	Non-growing patients with Class III malocclusion Follow-up of 6 months or longer	Patients with cleft lip palate and/or craniofacial syndromes or genetic problems Patients with temporomandibular joint disorders Treatment in growing patients
Intervention	Mandibular set back Bimaxillary surgery: (including maxillary advancement and mandibular set back) Surgery first	Maxillary advancement Patients treated with orthodontic or orthopedic appliances Studies not concerning surgical long-term stability
Outcome	Skeletal and dentoalveolar variables measured by lateral cephalometric radiographs	Studies providing no cephalometric measurements
Average time of follow-up	Studies with an average follow-up at least 2 years after surgery	Studies with no follow-up

significant reduction in SNB (WMD -3.95, 95%CI:-4.50, -3.40), significant rise in ANB (WMD 6.36, 95%CI:5.59, 7.13), significant growth in overjet (WMD 8.24, 95%CI: 6.56, 9.92), significant elevation in overbite (WMD 1.57, 95%CI: 0.30,2.84), while U1/SN (WMD -2.34, 95%CI, -6.27, 1.58) and L1/MP (WMD 2.12, 95%CI:0.43, 3.82) did not show any significant changes. After surgery T2– Last follow upT3, (T2–T3) Figures. 2b, 3b, 4b, 5b, 6b, 7b, and 8b.

The last follow-up showed no significant changes in SNA (WMD 0.06, 95%CI:-.05, 0.16), ANB (WMD 0.19,95%CI:-0.43 ,0.82), overjet (WMD -0.53, 95%CI: -1.36, 0.30), overbite (WMD 0.20, 95%CI:-0.17, 0.57), L1/MP (WMD -0.38, 95%CI:-1.67, 0.92), while there

Table 2. Keywords used for each data base search.

Pubmed	Web of science	Scopus	Embase	Cochrane
50	7	63	42	3
((((((("Malocclusion, Angle Class III"[Mesh] OR "class3"[Title/Abstract]) OR "class III"[Title/Abstract]) OR "Maxillary Deficiency"[Title/Abstract]) OR "mandibular protrusion"[Title/Abstract]) OR "Maxillary retrusion"[Title/Abstract]) AND ((((("Mandibular Osteotomy"[Mesh] OR "mandibular surgery"[Title/Abstract]) OR "bimaxillary surgery"[Title/Abstract]) OR "surgical orthodontics"[Title/Abstract]) OR "mandibular set back"[Title/Abstract])) AND (stability[Title/Abstract] OR relapse[Title/Abstract])	TI=("Malocclusion, Angle Class III" OR "class3" OR "class III" OR "Maxillary Deficiency" OR "mandibular protrusion" OR "Maxillary retrusion") AND TI=("Mandibular Osteotomy" OR "mandibular surgery" OR "bimaxillary surgery" OR "surgical orthodontics" OR "mandibular set back") AND TI=(stability OR relapse)	((TITLE-ABS-KEY ("Malocclusion, Angle Class III") OR TITLE-ABS-KEY ("class3") OR TITLE-ABS-KEY ("class III") OR TITLE-ABS-KEY ("Maxillary Deficiency") OR TITLE-ABS-KEY ("mandibular protrusion") OR TITLE-ABS-KEY ("Maxillary retrusion"))) AND ((TITLE-ABS-KEY ("Mandibular Osteotomy") OR TITLE-ABS-KEY ("mandibular surgery") OR TITLE-ABS-KEY ("bimaxillary surgery") OR TITLE-ABS-KEY ("surgical orthodontics") OR TITLE-ABS-KEY ("mandibular set back"))) AND ((TITLE-ABS-KEY (stability) OR TITLE-ABS-KEY (relapse)))	'malocclusion angle class iii':ab,ti OR 'class3':ab,ti OR 'class iii':ab,ti OR 'maxillary deficiency':ab,ti OR 'maxillary retrusion':ab,ti and 'mandibular osteotomy':ab,ti OR 'mandibular surgery':ab,ti OR 'bimaxillary surgery':ab,ti OR 'surgical orthodontics':ab,ti OR 'mandibular set back':ab,ti and 'stability':ab,ti OR 'relapse':ab,ti	("Malocclusion, Angle Class III" OR "class3" OR "class III" OR "Maxillary Deficiency" OR "mandibular protrusion" OR "Maxillary retrusion") AND ("Mandibular Osteotomy" OR "mandibular surgery" OR "bimaxillary surgery" OR "surgical orthodontics" OR "mandibular set back") AND (stability OR relapse)

was a significant change in SNB and U1/SN (WMD 0.38, 95%CI:0.24, 0.51) and (WMD 2.12, 95%CI:0.43, 3.82) respectively.

3.2. Subgroup analysis

A subgroup analysis based on the duration of follow-up: less than 2 years (group 1) and more than 2 years (group 2) was conducted to identify the source of the high heterogeneity and the influence of the follow-up duration.

SNA increased significantly after a 2 year-follow-up [WMD 0.07, 95%CI: 0.03, 0.11)] but no significant changes were noted in less than 2 year-follow-up [WMD -0.02, (95%CI: -0.23, 0.19)].

SNB did not have any significant changes in more than 2 year-follow-up [WMD 0.03 (95%CI: - 0.11, 0.18)]; however, it increased significantly in group 1 [WMD 0.76 (95%CI: 0.49, 1.03)].

There were no significant changes in ANB in both group 2 durations [WMD .047 (95%CI:-0.26,1.20)] or group 1 [WMD-0.49 (95%CI:-1.72,0.74)] durations.

For overjet, it decreased significantly after a 2 year-follow-up [WMD -0.80 (95%CI: -1.23, -0.36)], but not in less than a 2 year-follow-up [WMD -0.49 (95%CI: -1.38, 0.41)]. Overbite grew significantly in group 2 [WMD 0.50 (95%CI:0.01, 0.98)] and not in group 1 [WMD 0.03.

(95%CI: -0.36, 0.41)]. Only a few studies measured U1/SN and L1/MP; hence, the heterogeneity could not be measured due to the small sample size. The results of the statistical testing for heterogeneity and the corresponding funnel plots are given in Figures. 2c, 3c, 4c, 5c, and 6c.

3.3. Risk of bias within studies /publication bias

No publication bias was determined by using the Begg's test (in STATA 14 (StataCorp LP, College Station, USA)). The results of the Begg's test for the analysis of small study effect (publication bias) for the measurements of SNA, SNB, ANB, overjet, overbite, U1/SN, and L1/MP are as follows, respectively: 0.78, 0.33, 0.95, 0.08, 0.45, 0.98, and 0.34.

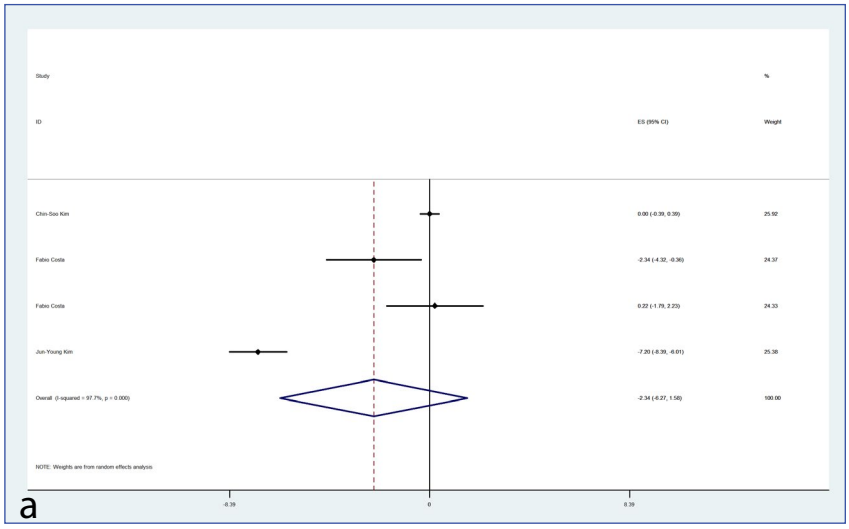

Figure 7a. Before surgery T1 - After surgery T2, (T1-T2) U1/SN.

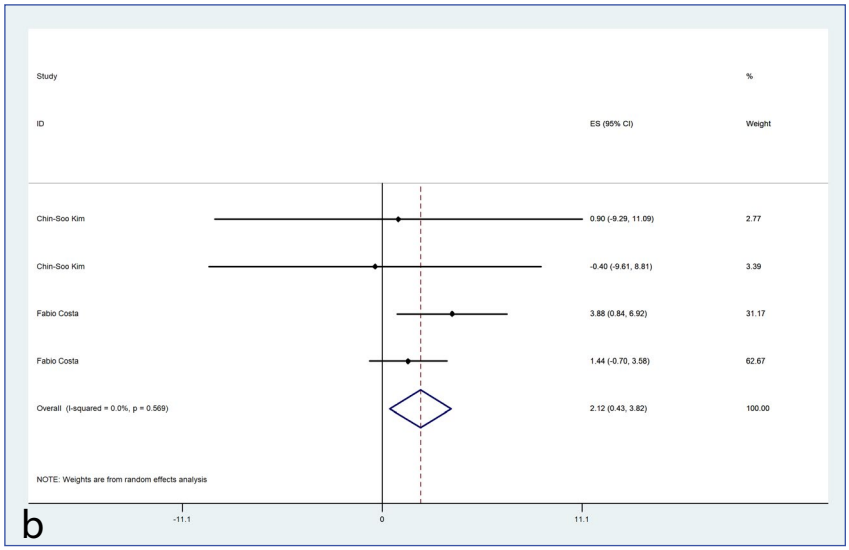

Figure 7b. After surgery T2 - Last follow-up T3, (T2-T3) U1/SN.

4. Discussion

4.1. Summary of evidence

This meta-analysis showed some significant relapse in skeletal and dental variables during the follow-up period. SNA and overbite increased significantly after a 2 year-follow-up . On the contrary, SNB increased significantly before a 2 year-follow-up . Overjet was significantly reduced after a 2 year-follow-up . To the best of our knowledge, this is the first meta-analysis reviewing the stability of skeletal class III malocclusion after bimaxillary surgery or mandibular setback.

Data from this study revealed that the main relapse in SNA occurred after a 2 year-follow-up but not in less than 2 years. This suggested that SNA relapse often happened after a 2 year-follow-up and was largely associated with the growth of maxilla that is a common finding in class III malocclusion.

For SNB, a significant increase was noted before a 2 year-follow-up and not after a 2 year-follow-up. This relapse in the short-term is due to the growth of mandible which reportedly can continue even after 18 years of age.[17] Hence, it is important to consider the patient's age and their related growth pattern before bimaxillary surgery and/or mandibular setback treatment.Overjet was reduced significantly in more than a 2 year-follow-up ; this relapse is due to an increase in SNB. However, the extent of overbite increased significantly after 2 years. Pre-surgical orthodontic treatment aims to decompensate incisor inclination toward normal values. Orthodontic decompensation allows a greater surgical correction, and this may be a more important factor in the relapse We should keep in mind that skeletal relapse is masked frequently by compensatory changes in the axial inclination of the teeth.[18-21]

Relapse varies considerably between patients and surgeons without any known reason. It is clear that good surgical training, profound experience in orthognathic surgery, and technical refinements by the surgeon are required to have perfect surgical outcomes with regards to esthetics and stability. The orthodontist should prepare the patient before surgery for a perfect coordination and leveling and alignment of both dental arches in transverse width, correct decompensation of the incisors, control of the surgical splint, and its newly defined occlusion

Table 3. Characteristics of the studies included in the systematic review.

Publication	Observation period	Group(s)	Participants (Number, sex, age)	Type of Surgery	Type of fixation	Country
Jeong et al[1], 2018	2 years	conventional bimaxillary surgery	14 (7M, 7F) / Mean age (21.5 ± 2.5)	Le Fort I Osteotomy & Bilateral IVRO*	Rigid	South Korea
		surgery first	17 (9M, 8F) / Mean age (20.3 ± 2.2)		Wire	
Choi et al[2], 2016	2 years	IVRO	15 (7M, 8F) / Mean age (22.1 ± 2.3)	IVRO	Intermaxillary Fixation	South Korea
		IVRO + Lefort 1	15 (7M, 8F) / Mean age (24.1 ±4.3)	IVRO + Lefort 1	Rigid	
Park et al[3], 2016	6 months	Conventional bimaxillary surgery	20 (13M, 7F) / Mean age (25.3)	Lefort 1 & BSSO**	Rigid	South Korea
		Surgery-first	20 (12M, 8F) / Mean age (22.6)			
Aydemir et al[4], 2015	5 years	BSSO with Semi Rigid Fixation and Lefort 1 with Rigid Fixation	26 / Mean age (17-29)	Lefort 1 & BSSO**	Semi Rigid and Rigid Fixation	Turkey
Kim et al [5], 2014	1 year	Bimaxillary Surgery Le Fort 1 and IVRO	37(20M,17F) / Mean age (23±4)	Lefort 1 & IVRO	Wire	South Korea
Kim et al [6], 2014	22 months	Conventional-BSSO	23 (14M, 9F)/ Mean age (23 ±6.3)	SF***	Rigid	South Korea
		Surgery first	38 (19M,19F)/ Mean age (21.6 ±3.5)	BSSO	Rigid	

Ko et al [7], 2013	1 year		45 (19M, 26F) / Mean age (23.2)	Lefort I & bilateral sagittal split osteotomy	Monocortical plates and screws in each side of the mandible and miniplates in each side of the maxilla	Taiwan
Jakobsone et al[8], 2011	3 years	Lefort 1 + BSSO	81 (55M, 26F) / Mean age (25.8 ± 9.5)	Lefort 1 + BSSO	Rigid	Norway
Abeltins et al[9], 2011	1 year	IVRO	21(6M,15F) / Mean age (20.2)	Lefort 1 + BSSO	Wire	Latvia
		BSSO	30(7M,23F) / Mean age (19.4)	Lefort 1 + IVRO		
Iannetti et al [10], 2007	2 years	Lefort 1	N/A / Mean age (18-36)	Bimaxillary	Rigid	Italy
		Lefort 1 + BSSO		Lefort 1		
Costa et al [11], 2006	1 year	rigid titanium	21 / Mean age (N/A)	Rigid resorbable plate	Rigid resorbable plate	Italy
		rigid resorbable plate		Rigid titanium	Rigid titanium	
Kwon et al [12] , 2000	7 months	Lefort 1 and BSSO	25 (13M, 12F) / Mean age (24.1)	Lefort 1 + BSSO	Rigid	Japan
McCance et al[13], 1992	1 year	Lefort 1 +BSSO	18 (N\A) / Mean age (N\A)	Lefort 1 + BSSO	Wire	England

Age is reported in years; N/A, Not available; M, Male; F, Female
*IVRO, Intra-oral vertical ramus osteotomy; **BSSO, Bilateral sagittal split osteotomy; SF***, Surgery First

Table 4. Outcomes in terms of cephalometric measurements of the studies included in the quantitative meta-analysis.

Article & year	Group	Outcome				
		Before surgery (T1)	After surgery (T2)	T1-T2	Last Follow-up (T3)	T2-T3
Jeong et al[1], 2018	Conventional bimaxillary surgery	N/A	N/A	SNA: 0.4±2.3 SNB: -4.9±2.1	N/A	SNA: -0.1±1
	surgery first	N/A	N/A	SNA: 0.3±2.3 SNB: -5.7±2.6	N/A	SNA:0.1±0.9
Park et al[3], 2016	Conventional bimaxillary surgery	N/A	N/A	SNA: - 2.8±1.9 SNB: -3.7±1.6	N/A	SNA:0.3±1.4 SNB: 0.2±0.8
	Surgery-first	N/A	N/A	SNA: -2.5±2.3 SNB: -3.2±1.9	N/A	SNA:0.4±1.3 SNB: 0.7±1.0
Aydemir et al[4], 2015	BSSO with Semi Rigid Fixation and Lefort 1 with Rigid Fixation	SNA: 78.9± 2.9 SNB: 83.1± 3.9 ANB: 24.2±3.1 OJ: 27.0± 3.5 OB: 22.3± 2.6	SNA: 82.9±2.5 SNB: 82.4±2.9 ANB: 0.5± 2.5 OJ: 2.6 ±3.4 OB: 1.3 ±1.7	SNA: 4.1±2.3 SNB: -1.4±2.6 ANB: 5.5±2.3 OJ: 9.6±3.7 OB: 3.1±3.6	SNA:83.0 ±3.0 SNB:81.4± 3.6 ANB:1.6 ± 2.2 OJ: 3.0 ± 1.0 OB:1.4 ± 0.6	SNA: 1.1± 0.3 SNB: -1±0.4 ANB: 1.1±0.1 OJ: 0.4±5.9 OB: 0.1±1.2
Kim et al [5], 2014	Bimaxillary Surgery Le Fort 1 and IVRO	SNA: 81.4±2.7 SNB: 83.8±3.7 U1/SN: 115.1±5.5 IMPA: 84.9±6.7	SNA: 81.94±2.9 SNB: 79±3.2 U1/SN: 107.9±5.4 IMPA: 83.2±5.9	SNA: 0.6+_1.1 SNB: -4.9±2.4 U1/SN: -7.2±3.7 IMPA: -1.7±3.9	SNA: 82±3.1 SNB: 79.1±3.1 U1/SN: 106.3±7.2 IMPA: 84±5.9	SNA: 0.1±0.0 SNB: 0.1±0.0 U1/SN: 0.6±0 IMPA: 1.2±1.2
Kim et al [6], 2014	Conventional-BSSO	SNA: 81±3.8 SNB: 83.5±4.3 ANB: -2.5±2.8 IMPA: 92.6±5.9 OJ: -6.2±3.4	N/A	SNB: -4.7±1.9 IMPA: 0±0 OJ: 10.1±3.5 OB: 0.1±1.4	N/A	SNB:0.9±0.8 IMPA: -8.9±5 OJ: -0.8±1.2 OB:0.2±0.6

		OB: 0.9±1.3				
	Surgery first	SNA: 80.5±4.1 SNB: 83.5±4.1 ANB: -3±2 IMPA: 82.3±9.3 OJ: - 4.4±2.9 OB: 0.7±2	N/A	SNB: -4.4±1.3 IMPA:0.7±2.2 OJ:9.3±4.4 OB: 0.8±2.1	N/A	SNB: 1.1±0.7 IMPA: -0.6±5.7 OJ: -2.3±3.1 OB: -0.3±0.9
Jakobsone et al[8], 2011	Lefort 1 + BSSO	SNA: 79.6±3.6 SNB: 84.7±5.5 ANB: -5.1±4.1 OJ: -7±5 OB: -1.8±3.8	N/A	SNA: 3.3±2.1 SNB: -4±3 ANB: 7.3±3.4 OJ: 9.8±4.6 OB: 3.7±3.5	N/A	SNA: -0.1±0.9 SNB: 1±1.2 ANB: -1±1.2 OJ: -0.8±2 OB: 0±0.7
Abeltins et al[9], 2011	IVRO	SNA: 80.7±3.7 SNB: 84.9±4.9 ANB: -4.2±3.3	N/A	N/A	N/A	N/A
	BSSO	SNA: 79.3±3 SNB: 83.6±3.7 ANB: -4.2±3	N/A	N/A	N/A	N/A
Iannetti et al [10], 2007	Lefort 1	N/A	N/A	SNA: 0.1±0.1	N/A	SNA:0.1±0.1 SNB:0.1±0.1 ANB:01±0.2
	Lefort1+BSSO	N/A	N/A	SNA: 0.1±0.1	N/A	SNA:0.1±0.1 SNB: -0.5±0.3 ANB: 0.6±0.3
Costa et al [11], 2006	Rigid titanium	SNA: 78.4±2.8 SNB: 81.9±3.8	SNA: 81.7±2.9 SNB: 80.7±3.7	SNA: 3.3±1.6 SNB: -2.2±2.9	N/A	SNA: -0.1±0.6 SNB: 0.9±1.1

		ANB: -3.5±2.7 U1/SN: 111.2±7.8 IMPA: 88.3±7.1 OJ: -4.6±3.8 OB: 1.1±21	ANB: 1±2.4 U1/SN:112.7± 8.4 IMPA: 87.7±7.8 OJ: 3.2±1.31 OB: 2.3±1.4	ANB: 5.5±2.8 U1/SN: -2.3±3.5 IMPA: -0.2±2.7 OJ: 7.9±3.5 OB: -0.4±2.1		ANB: -0.9±1.3 U1/SN: 3.9±5.4 IMPA: -0.4±4.1 OJ: -0.1±1.7 OB: 1.6±1.9
	Rigid resorbable plate	SNA: 80±3.6 SNB: 82.9±3.3 ANB: -2.9±0.8 U1/SN: 105.8±7.1 IMPA: 85.6±5.6 OJ: -5.1±1.9 OB: 0.8±2.1	SNA: 82.4±3.9 SNB: 80.3±3.6 ANB: 2.1±1.9 U1/SN: 107.4±7.4 IMPA: 86.1±6.5 OJ: 2±1.0 OB: 2.8±0.8	SNA: 3±1.28 SNB: -3.6±1.5 ANB: 6.6±1.4 U1/SN:3.1±9 IMPA:2.4±3.3 OJ: 8.2±2.4 OB: 0.9±2.4	N/A	SNA: -0.6±1.2 SNB: 1.1±0.6 ANB: -1.7±1.0 U1/SN: 1.4±3.3 IMPA: -1.9±2.9 OJ: -0.4±0.8 OB: 0.3±1.1
Kwon et al [12] , 2000	Lefort 1 and BSSO	N/A	N/A	OJ: 9.1±4.6 OB: 2.5-±3	N/A	OJ: -0.6±1.4 OB: -0.1±2.0
McCance et al[13], 1992	Lefort 1 +BSSO	SNA: 78.2±4.3 SNB: 83±4.4 ANB: -4.8±1.9 IMPA: 85±11 OJ: -4.1±3 OB: -6.3±3.8	SNA: 82.3±3.4 SNB: 81.4±2 ANB: 1.3±1.2 IMPA: 83.3±6.3 OJ: -0.9±1.1 OB: 2.4±1.2	SNA: 4.1±1 SNB: -2±2.0 ANB: 5.9±0.0 IMPA: -1±2.0 OJ: 2.4±4 OB: 3.2±3.6	N/A	SNA: -0.1±0.0 SNB: 0.4±1 ANB: 0.2±0.4 IMPA: -0.5±0.5 OJ: 0.8±0.0 OB: -0.7±0.5

Data are presented as means ± standard deviations
OB, Over bite; OJ, Over Jet, BSSO, Bilateral sagittal split osteotomy; IVRO Intra-oral vertical ramus osteotomy, SF, Surgery-First

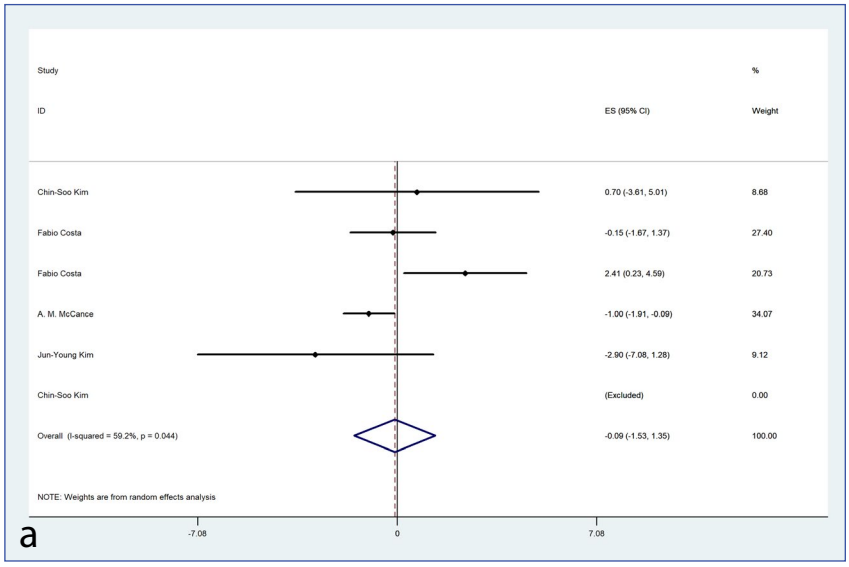

Figure 8a. Before surgery T1 - After surgery T2, (T1-T2) L1/MP.

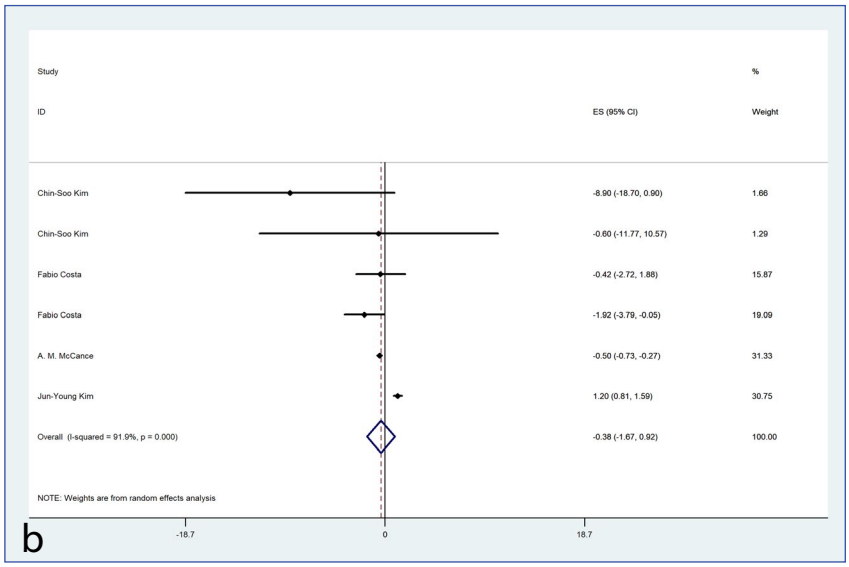

Figure 8b. After surgery T2 - Last follow-up T3, (T2-T3) L1/MP.

to allow correct placement of the mandible during surgery. The etiology of relapse is multifactorial, including, but not limited to: the proper seating of the condyles, the extent of mandibular setback and maxillary advancement, the soft tissue and muscles, the mandibular plane angle, the remaining growth and remodeling, the skill of the surgeon, and the pre-operative age of the patient [8]. Proffit et al [22] questioned the stability in orthognathic surgery since the stability of the surgical repositioning of the jaws varies considerablydepending on the procedure. In their view, the order of importance starts with the direction of movement, the type of fixation used, and in the end, the surgical technique that has been adopted.

4.2. Limitations

This meta-analysis might be considered a first step in addressing the stability of skeletal class III malocclusion after bimaxillary surgery or mandibular setback. Although this study provided an overview of the topic, there were several limitations. One main limitation was the shortage of large and high-quality RCTs. The numbers of relevant research articles and patients included in the meta-analysis were not large enough. Furthermore, the sample sizes were diluted due to too many study variables included (7 cephalometric variables at 3 different time points). Hence, the quantitative.

analysis cannot accurately reflect real skeletal and dental changes. Additionally, not every study included looked at all variables further complicating the analysis. Eventually, some studies proposed surgery first which were deleted from the analysis; however, whether the treatment effects of surgery first can be stable remains unclear. Attention should also be paid to the stability of the treatment effects of surgery first. Therefore, future research in this area is warranted.

5. Conclusions

On the basis of this review, we concluded the following:

1. Surgical orthodontic improves sagittal skeletal and dental relationships but significant relapse during the follow-up period may happen.

2. SNA and overbite increased significantly after a 2 year-follow-up .
3. SNB increased significantly before a 2 year-follow-up with no significant changes after this follow-up.
4. Overjet diminished significantly after a 2 year-follow-up

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Author Contributions
AJ: conceptualization, study design, study concept, original writing and corresponding author. LN: drafting, data interpretation, drawings and editing. MT and AD: literature review, search design, data gathering. AF and MA: software programs and statistical analysis. CWW: drafting, data interpretation, critical revision and final approval.

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Questions

1. Which one is correct regarding stability after surgery.

❑a. Single jaw surgery has greater relapse than two jaw surgery;
❑b. Two jaw surgery has greater relapse than single jaw surgery;
❑c. There is a controversy regarding the stability of single and two jaw surgery;
❑d. None of them.

2. What are the causes of late relapse after orthognathic surgery?

❑a. Unstable occlusal relationships;
❑b. Absence of myofunctional adaptation;
❑c. Persistent tongue or orofacial muscle habits;
❑d. All of them.

3. How much of the Class III malocclusions have true mandibular prognathism?

❑a. 5% to 10%;
❑b. 20% to 25%;
❑c. 30% to 50%;
❑d. 50% to 70%.

4. How much of the of all class III malocclusions have some degree of maxillary retrusion?

❑a. 15%;
❑b. 25%;
❑c. 50%;
❑d. 75%.