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REVIEW

The Factors Affecting Long-Term Stability in Anterior Open-Bite Correction - A Systematic Review

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ABSTRACT

Objective: The present systemic review was conducted with the main purpose to evaluate the quantitative effects of orthognathic surgeries, extraction versus non-extraction treatment, and the type of malocclusion in the stability of anterior open-bite (AOB) correction over the long-term.

Methods: The systematic search for studies was conducted through MEDLINE, CINAHL, EMBASE, Scopus, PsychINFO, various key journals, and review articles; November 30, 2016, was the last date for the search. The Quality Assessment Tool for Quantitative Studies was used to grade the methodological quality of the studies.

Results: The present review included 14 studies. Stability of the corrected AOB ranged from 61.9% to 100%. The studies with orthognathic surgeries showed a stability of 70–100%. The studies without orthognathic surgeries showed the stability of 61.9–96.7%. All of the studies were retrospective. The mean change in AOB before (T1) and after treatment (T2-T1) was 0.1 mm to 6.93 mm and the mean change in overbite from T2 to T3 (T3-T2) was −0.06 mm to 2.5 mm.

Conclusion: Studies with orthognathic surgeries presented with high amount of long-term stability in corrected AOB. No significant difference was noticed in relation to the type of malocclusion and extraction or non-extraction cases.

Keywords: Anterior open-bite, systematic review, stability

INTRODUCTION

Anterior open-bite (AOB) is a malocclusion that is characterized by decrease in the normal vertical overlap between upper and lower incisal edges when the molars are in occlusion (1). It may be either dentoalveolar open-bite resulting from mechanical blockage of vertical development of the anteriors and alveolar component or skeletal open-bite resulting from vertical skeletal discrepancy (1,2). Along with AOB, subjects may also present with incompetence of lips, convex facial profiles, marked labial inclinations, and crowding of the incisors, leading to impairment of mastication and phonetics with considerable esthetic problems (2). Many treatment modalities have been developed to treat both dental and skeletal open-bites. Treatment ranges from functional appliances to fixed appliances with or without surgical correction. The treatments like vertical chin cup therapy, chewing exercises, bite blocks, extractions, and mesialization of posterior teeth were used to achieve relative and true molar intrusion (3-5). Palatal cribs or spurs are recommended when thumb sucking or tongue thrusting is noticed (6). Although these treatments increase vertical overlap of the incisors, it is still not clear which treatment modality is more efficient and effective than others. Additionally, various factors determine the long-term stability of corrected AOB malocclusion (3-5). They include severity of AOB malocclusion prior to treatment, extractions of premolars, correction of open-bite with or without orthognathic surgery, or different methods of retention (4,5). Recently, many studies have been conducted to check the long-term stability of corrected AOB malocclusion (7-24). When we searched the literature, we came across two systematic reviews of case series studies conducted to assess the effectiveness of orthodontic and orthopedic treatment in AOB correction (4,5). No systematic reviews have been conducted recently to check the long-term stability of AOB correction. The present systematic review was conducted to evaluate the factors affecting long-term stability in open-bite correction.

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METHODS

The planning, conduct, and reporting of present review was in adherence to PRISMA standards of quality for reporting systematic reviews and meta-analyses (26). IRB approval was not required. The present review was registered in PROSPERO with registration number CRD42016053399.

Questions

We intended to examine the quantitative effects of orthognathic surgeries, extraction versus non-extraction treatment, and the type of malocclusion in the stability of AOB correction over the long-term.

Study Eligibility

Only studies published in English that investigated the stability in AOB correction over the long-term with or without orthognathic surgery were included. Papers were not included if they were editorial letters, case reports, in vitro studies, studies which are not investigating the long-term stability in AOB correction (stability of outcome assessed at the posttreatment follow-up ≤1 year), studies with syndromes, and studies with cleft lip or palate.

Study Identification

With the focus on the study strategy, MEDLINE, CINAHL, EMBASE, the Web of Science, PsychINFO, the Educational Resources Information Center, and Scopus were searched using search terms designated by an experienced research librarian ("open-bite," "anterior open-bite," "stability," "recur," "relapse," "instability," "retreat," "post treatment effect," "treatment outcome," "follow-up"). The additional search was performed through the tables of contents of the American Journal of Orthodontics and Dentofacial Orthopedics, the European Journal of Orthodontics, the Angle Orthodontist, and the Journal of Clinical Orthodontics for relevant articles as of November 30, 2016, the last date for the search. The reference lists of all the included articles were searched for further additions.

Study Selection

We screened all titles and abstracts independently and in duplicate for inclusion. In the event of disagreement or insufficient information in the abstract, we independently and in duplicate reviewed the full text of potential articles. The interrater agreement for study inclusion, as assessed using an intraclass correlation coefficient, was 0.65. Conflicts were resolved by consensus discussion between the two reviewers. The Quality Assessment Tool for Quantitative Studies was used to evaluate the risk of publication bias (27).

Data Extraction

The extraction of data was done by two reviewers independently and in duplicate for all variables, and the consensus method was used to resolve conflicts. The Quality Assessment Tool for Quantitative Studies, developed for the Effective Public Health Practice Project, and adapted by Thomas et al. (27), the Quality Assessment Tool for Quantitative Studies, which is found to have content and construct validity and excellent interrater reliability (27-29), was used to grade the methodological quality of these studies. The following six criteria were considered by this tool: bias in the study selection, study design, confounders, blinding, method of data collection, and dropouts/withdrawals. According

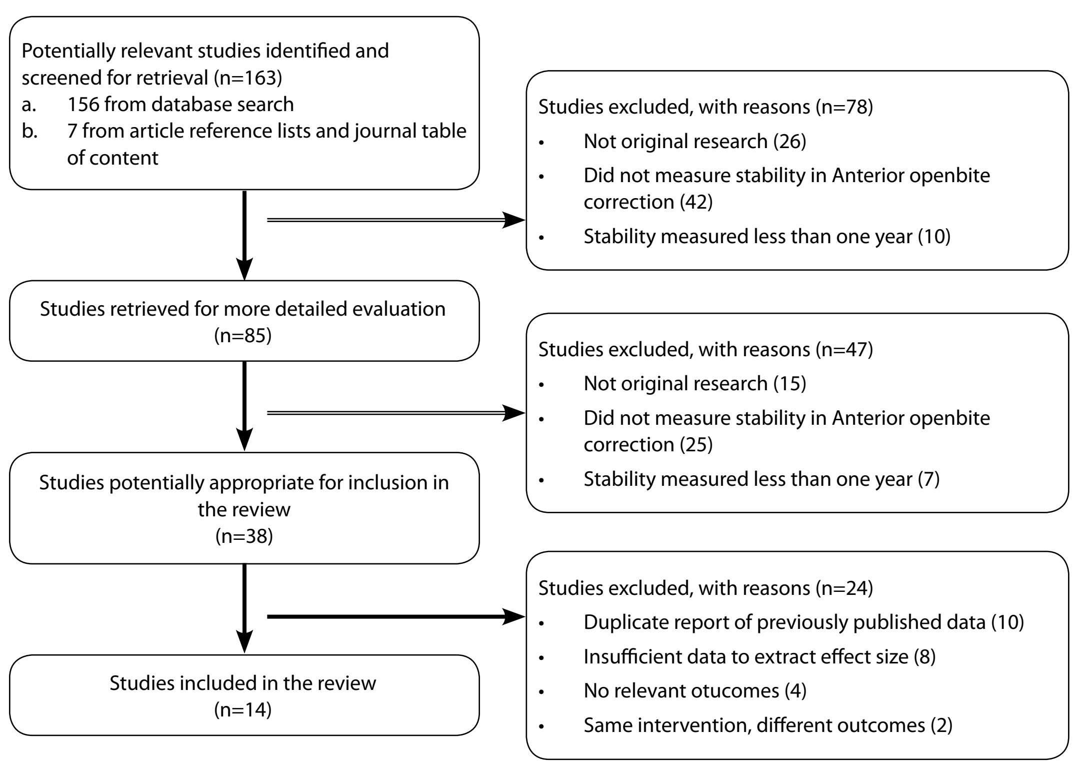

Figure 1. Study selection flow diagram

to the directions of the tool, each criterion was rated as strong, moderate, or weak. Depending on the rating, overall assessment of the study was determined according to the guidelines of the tool (strong: weak rating nil, strong rating ≥4; moderate: weak rating 1, strong rating <4; weak: ≥2 weak ratings).

Data Synthesis

The data extracted from each included study comprised the prime author, year of publication, study type, study quality, sample size, molar classification, extraction or non-extraction treatment, surgery conducted, treatment type, open-bite measurement (before, after, and long-term treatment), statistical analysis used, and the authors' conclusions.

RESULTS

Trail Flow

The planned search strategy yielded 156 articles with an additional 7 identified through review of journal indices and references. Among these, 14 articles were identified for inclusion in the present systematic review (Figure 1).

Study Characteristics and Study Quality

All the included studies were published in English and were fairly recent, with the oldest study published in 2000. Out of fourteen studies included in the review, nine (64.29%) studies did not use any type of orthognathic surgeries to correct AOB, and five

Table 1. Descriptive data and quality assessment of included studies

Author/year	Study design	AOB inclusion criteria	Intervention type	Surgery	Statistical analysis	Study conclusion	Study quality
Vela-Hernandez et al. (18)	Re	AOB ≥1mm, SOB	Tip EA, BRB on MX molars	Nil	ANOVA	Mean AOB increased to 3.98 mm, R of 0.56 mm	Strong
Marzouk et al. (20)	Re	AOB of -0.3 mm to -8mm	EA mandibular rotation and MI and incisor extrusion	MS fixed at zygomatic buttress	Paired t-test	S: 88.82% R: 11.18%, no difference in type of malocclusion and S	Moderate
Salehi et al. (9)	Re	AOB ≤0 mm up to -3 mm	EA with HG or bite plane	Nil	Independent t-test and ANOVA	83.4% of S with 16.6% of R	Moderate
Scheffler et al. (8)	Re	AOB of range -5.0 0 mm -1.8 mm	MIS, MS/MP, NTC, and EA	Nil	MRA	96.7 % of S; no difference in type of malocclusion and S	Strong
Mucedero et al. (19)	Re	TS, negative AOB	QH	Nil	Mann-Whitney U test	AOBC: 24 (86%) S: 93%	Moderate
Geron et al. (17)	Re	AOB of ≤0 mm	Lingual bracket jig and PBB	Nil	Two-way ANOVA	87.5% of S; no difference in group; extraction and non-extraction no difference with type of occlusion and S	Moderate
Silva et al. (15)	Re	AOB of 2 mm	NA	LIO at least two segments	Mann-Whitney U test	70% of S	Moderate
Fontes et al. (16)	Re	No overlap of incisors	NA	BSO	Repeated ANOVA	90% of S, Class II more relapse compared to Class III and Class I	Strong
Teittinen et al. (13)	Re MX vs. BM	Skeletal AOB, subjects treated with LIO, RIF	Straight wire	LIO and MI MO	Paired t-test	M: 100% of S BM:75% of S, Class II cases with low facial height more S than Class III	Moderate
Remmers et al. (7)	Re	AOB of <0 mm	EA with HG or FA	Nil	Nomogram and LRA	72.97% of S with 27% relapse; no difference in extraction and non-extraction group	Moderate
Espeland et al. (12)	Re	AOB of 0.3 mm to -6.8 mm	EA	One-piece LIO	Paired t-test	87.5% of S, overall relapse significantly higher in Class II than in Class III	Moderate
Janson et al. (10)	Re NE vs. E	AOB of at least 1 mm	EA with AVE	Nil	Independent t-test	NE: -61.9% of S, E: 74.2% of S; no difference in malocclusion type and S	Moderate
Swinnen et al. (14)	Re MI vs. MEx	Skeletal AOB with no vertical	NA overlap, treated with LIO	LIO, MI, and MEx	Mean and standard deviation	100% of S in both groups; no difference in malocclusion type and S	Weak
Kim et al. (24)	Re	AOB of 0.5 mm	MEAW with AVE	Nil	Paired t-test	G: 94.4% of S, 0.23 mm R NG: 90% of S, 0.35 mm of R; no difference in extraction and non-extraction group	Moderate

Re: retrospective; MSSO: mandibular sagittal split osteotomy; MEAW: multiloop edgewise archwire; EA: edge wise appliance; QH: quad helix appliance; BRB: bonded resin blocks; AVE: anterior vertical elastics; HG: head gear; FA: functional appliance; PBB: posterior bite block; MIS: maxillary intrusion splint; MS/MP: miniscrew/miniplates; NTC: nickel titanium coil spring; NE: non-extraction; E: extraction; LIO: LeFort I osteotomy; BSO: bilateral sagittal split osteotomy; MX: maxillary; BM: bimaxillary; MI: maxillary impaction; MEx: maxillary extrusion; MO: mandibular osteotomy; NA: not available; AOBC: anterior open-bite correction; S: stability; AOB: anterior open-bite; SOB: skeletal open-bite; R: relapse; TS: thumb sucking; LRA: logistic regression analysis; MRA: multivariate regression analysis; ANOVA: analysis of variance

Table 2. Summary of sample size, malocclusion type, extraction, retainers used, treatment duration, and anterior open-bite measurement

Author	Sample size (male, female)/ mean age in years	Malocclusion	Surgical fixation	Extraction	Measurement technique	Retainers MX/MN	Mean active treatment duration	AOB measurement
Vela-Hernandez et al. (18)	31 (17, 14)/ 26.6	Skeletal Class I, no recording of OH	Nil	NE	LC	F/MX, MN anterior lingual, R/MX, MN at night	17.2 m	+1i and -1i perpendicular to OP
Marzouk et al. (20)	26 (11, 15)/22.5	Class I: 16 Class II: 10	MP fixed at zygomatic buttress	E	LC	R/MX with posterior bite plane, MN worn full time for one year	26.2 m	+1i and -1i perpendicular to VP
Salehi et al. (9)	37 (20, 17)/18	Skeletal AOB with Jaraback Index <65%	Nil	E – 22 NE -15	LC	F/MX and MN	20.3 M	+1i and -1i
Scheffler et al. (8)	30 (11, 19)/24.1	Class II and Class III, treated with intrusion of posterior MX teeth	MP/MS at the base of ZA	NE	LC	F/MX	1.6 y	NA
Mucedero et al. (19)	28 (11, 17)/8.2	Skeletal Class II	Nil	NE	LC	NA	1.4 y	NA
Geron et al. (17)	39 (5, 34)/27.23	Class I: 10, Class II: 16, Class III: 13	Nil	E -24 NE -15	LC	F/Mx Mn for two years, R/Mx MN one night in a week	18 m	+1i and -1i
Silva et al. (15)	33 (11, 22)/23	Skeletal AOB	IMF with elastics	NE	LC and dental cast	NA	2 y	+1i and -1i
Fontes et al. (16)	31 (5, 26)/26.9	Class I: 14, Class II: 15, Class III: 2	Rigid internal fixation	NE	LC	NA	10.6 m	+1i and -1i parallel to MOP
Teittinen et al. (13)	M: 12 /29.3 BM: 12 /30.8	M: Class II, BM: Class III	Rigid internal fixation	NE	LC	NA	NA	+1i and -1i perpendicular to NM
Remmers et al. (7)	52 (17, 35)/12.4	Skeletal Class II	Nil	E-17 NE - 35	LC and dental cast, PAR	NA	2.1 y	+1i and -1i perpendicular to NM
Espeland et al. (12)	40 (16, 24)/25.8	Mixed (Class I: 10, Class II: 13, Class III: 17)	Rigid, with MP/MS	NE	LC	NA	5.9 m	+1i and -1i parallel to SN
Janson et al. (10)	NE: 21 (5, 16) / 12.4 E: 31 (8, 23)/ 13.22	NE: Class I-21, E: Class I: 16, Class II: 15	Nil	E-31 NE-21	LC	R/MX, F/MN	NE: 2.4 y E: 2.46 y	+1i and -1i perpendicular to functional OP
Swinnen et al. (14)	MI:38 (10, 28) / 20.9 MEx:11 (8, 3) / 20.9	Class II and Class III with skeletal open-bite	Rigid internal fixation	NE	LC	Surgical fixation	NA	+1i and -1i parallel to SN
Kim et al. (24)	G – 29 (8, 21)/ 13.5 NG – 26 (5, 21)/26.1	No information about type of malocclusion, inclusion of TS and TT	Nil	G -E in 18 NE-11 NG–E in 15 NE -11	LC	F/MX, 6 weeks full time, later half-time	G – 27 m, NG – 17 m	NA

2MX: maxillary arch; MN: mandibular arch; G: growing group; NG: non growing group; Mixed: Class I, Class II, and Class III malocclusion; NA: not available; Y: yes; m: months; y: years; F: fixed; TS: thumb sucking; TT: tongue thrusting; PAR: peer assessment rate; LC: lateral cephalometry; M: maxillary; BM: bimaxillary; g1: grade 1 with apical blunting; g2: grade 2 with moderate resorption; IMF: intermaxillary fixation; +1i: incisal edge of upper incisor; -1i: incisal edge of lower incisor; SN: Sella-Nasion line; NM: Nasion-Menton line; OP: occlusal plane; MOP: maxillary occlusal plane; VP: vertical reference plane; OH: oral habits; MP: miniplate; MS: miniscrew; ZA: zygomatic area

(35.71%) used orthognathic surgeries. Stability of the corrected AOB ranged from 61.9% to 100%. The studies with orthognathic surgeries showed a stability of 70–100%. The studies without orthognathic surgeries showed the stability of 61.9-96.7%. All of the studies were retrospective. The quality assessment rated three of the studies as being of strong quality, ten of the studies as being of moderate quality, and one of the studies as being of weak quality (Table 1).

The number of study participants ranged from 13 to 55 (total n=509), with a mean of 36.35. The mean active treatment duration varied from 5.9 months to 28 months. In eight (57.14%) of the studies included in the systematic review, AOB was corrected without extraction, and five (35.71%) studies compared extraction and non-extraction methods to treat AOB (Table 2).

Table 3 shows the results of the included studies. The mean value of AOB before the start of treatment (T1) ranged from −0.63 mm to −4.75 mm. During T2 the mean overbite ranged from 0.2 mm to 2.6 mm. During T3 the mean overbite values ranged from −0.4 mm to 1.85 mm. The mean change in AOB before (T1) and after treatment (T2-T1) was 0.1 mm to 6.93 mm, and the mean change in overbite from T2 to T3 (T3-T2) was −0.06 mm to 2.5 mm.

DISCUSSION

Long-term stability of corrected AOB depends on various factors like severity of AOB before treatment, mandibular plane angle, anterior facial height prior to treatment, ages of the individuals at the start of treatment, whether the correction was done with or without orthognathic surgery or extraction, soft tissue forces such as abnormal tongue position, surgical fixation, and bone remodeling, etc. (3-25). The present systematic review was conducted to examine the factors affecting long-term stability in AOB correction.

Table 3. Summary of results of included studies (AOB Before, after, and long-term follow-up)

Author		Follow-up	T1 AOB mm, mean (SD)	T2 AOB mm mean (SD)	T3 AOB mean (SD)	T2-T1 mm mean (SD)	T3-T2 mm mean (SD)	Relapsed at follow-up n (%)
Vela-Hernandez et al. (18)		32.9 m	-2.48 (1.57)	1.50 (0.47)	0.94 (0.57)	3.98 (1.66)	-0.56 (0.60)	NA
Marzouk et al. (20)		4 y	-4.75 (2.27)	2.18 (0.48)	1.41 (0.39)	6.93* (1.99)	-0.77 (0.43)	3 (11.18)
Salehi et al. (9)		4.2 y	-0.63 (0.76)	1.62 (0.50)	1.16 (0.88)	2.25 (0.62)	-0.46 (0.7)	6 (16.6)
Scheffler et al. (8)		2 y	-1.2 (1.7)	2.2 (1.6)	-0.4 (1.1)	NA	NA	1 (3.3)
Mucedero et al. (19)		5 y	-3.3 (1.6)	0.9 (0.63)	0.61 (0.12)	4.2 (1.8)	0.7 (1.6)	4 (14.3)
Geron et al. (17)		4.01 y	-2.2 (1.9)	0.98 (0.57)	1.1 (0.7)	NA	NA	5 (12.5)
Silva et al. (15)		2.5 y	-4.3 (0.43)	2.6 (0.15)	1.65 (0.14)	NA	NA	10 (30)
Fontes et al. (16)		4.5 y	-2.6 (1.1)	0.6 (1.0)	1.0 (1.0)	NA	NA	1 (10)
Teittinen et al. (13)	M	3.5 y	-2.55 (1.41)	1.23 (1.05)	1.85 (0.93)	NA	0.59 (1.40)	0
	BM	2 y	-2.19 (1.44)	0.98 (1.53)	0.73 (0.93)	NA	-0.25 (1.33)	3 (25)
Remmers et al. (7)		5 y	-3.2 (1.9)	0.4 (1.1)	0.2 (1.8)	3.6 (2.1)	-0.1 (1.4)	10 (27)
Espeland et al. (12)		3 y	-2.6 (1.7)	1.50 (3.60)	1.10 (1.20)	3.6 (1.7)	0.1 (1.4)	5 (12.5)
Janson et al. (10)	NE	5.22 y	-1.75* (0.66)	1.43 (0.50)	0.07* (0.62)	3.19 (0.72)	-1.36* (0.54)	8 (38.1)
	E	8.35 y	-2.73 (1.80)	1.09 (0.94)	1.02 (1.62)	3.83 (1.94)	-0.06 (1.50)	8 (25.8)
Swinnen et al. (14)	MI	1 y	-0.7	1.3	1.8	NA	0.8*	0
	MEx	1 y	-2.1	0.2	0.8	NA	1.2	0
Kim et al. (24)	G	35 m	-2.27 (2.10)	1.58 (0.81)	1.18 (1.01)	3.85*	-0.23	1 (6)
	NG	28 m	-2.23 (2.10)	1.78 (0.84)	1.55 (1.09)	4.01*	-0.35	2 (10)

AOB: anterior open-bite; NA: not available; N: no relapse; G: growing group; NG: non-growing group; m: months; y: years; M: maxillary; BM: bimaxillary
*p<0.05

In the present systematic review, the mean AOB before treatment ranged from -0.63 mm to −4.75 mm. Marzouk et al. (20) noticed the initial AOB of −4.75 mm. The mean amount of correction at T2 varied from 0.2 mm to 2.6 mm, with highest (2.6 mm) correction noticed by Silva et al. (15). During the follow-up periods, which ranged from 1 year to 8.35 years, the mean amount of relapse varied from −0.4 mm to 1.85 mm. The highest amount of relapse (1.85 mm) was noticed by Teittinen et al. (13) with maxillary alone orthognathic surgery.

Proffit and Phillips (25) suggested that the stability of the corrected AOB malocclusion should be reported as a percentage of patients with a significant posttreatment change for the given treatment. The condition is considered "highly stable" if significant posttreatment changes are noticed in less than 10% of the patients and "stable" if it is less than 20% and almost none have major posttreatment changes. Alternatively, stability can be interpreted by using set metric cut-off values. Posttreatment changes greater than 2 mm are considered clinically significant, and changes greater than 4 mm are considered highly clinically significant (13). In the present review, none of the included studies showed posttreatment change of greater than 2 mm.

Stability of Corrected AOB with or without Extraction

Anterior open-bite malocclusions can also be treated by extraction of molars or premolars, which in turn leads to forward movement of posterior teeth in an attempt to achieve an counter-clockwise rotation of the mandible (10). In the present systematic review, eight studies used the non-extraction method to correct AOB (8,12-16,18,19), five studies used extraction and non-extraction patients (7,9,10,17,24), and one study used only extraction cases (20). Out of five studies that compared extraction and non-extraction methods to treat open-bite malocclusion, four studies (7,9,17,24) did not find any statistically significant difference between extraction and non-extraction methods in long-term stability of treated open-bite, whereas the study by Janson et al. (10) showed that the subjects with extraction presented with a high level of stability (74.2%) compared to non-extraction cases (61.9%).

Type of Malocclusion and Long-Term Stability of Corrected AOB

Open-bite with Class II malocclusion/long-face patients tend to relapse more compared to Class I or Class III malocclusion (13). The reason for high relapse among long-face patients may due to the need for large amount of mandibular advancement, which in turn leads to relapse among corrected AOB subjects in the absence of adequate muscular adaptation. In addition, subjects with preoperative high mandibular plane angles have high risk of condylar resorption with bite opening after orthognathic surgery. In the present review, eight studies (8,10,12–14,16,17,20) used mixed malocclusion (Class I, Class II, and Class III). Out of eight studies, five studies did not find any significant difference in malocclusion type and long-term stability of corrected AOB (8,10,14,17,20), and two studies showed significant relapse in Class II cases compared to Class III (12,16). The study by Tietten et al. (13) showed Class II cases with low facial heights have less relapse compared to Class III subjects with high mandibular plane angles.

Type of Orthognathic Surgery and Stability in Corrected AOB

Surgical correction of AOB includes performing the LeFort I osteotomy (LIO) alone or in combination with mandibular ramus osteotomy, which in turn repositions the maxilla, allowing the counter-clockwise rotation of the mandible (22). Orthognathic surgery results in three-dimensional correction of skeletal and dentoalveolar components in patients with severe AOB. The studies have shown that postoperative stability in AOB correction is influenced by the type of orthognathic surgery. Maxillary repositioning by LIO proves to be more stable compared to mandibular sagittal split osteotomy, because muscular activity has little influence on maxillary procedures, which allows correction of lip to incisor relationship. Skeletal AOB is corrected by bimaxillary surgery, especially when repositioning of the mandible is required. AOB corrected with mandibular surgery increases posterior facial height, which in turn increases the relapse potential of corrected AOB. In the present review, five studies (12–16) used orthognathic surgeries to correct skeletal AOB. Out of five studies that used orthognathic surgery, one-piece LIO was performed in three studies (12–14), and stability of corrected AOB ranged from 87.9% to 100%. Studies with more than one-piece LIO or sagittal split osteotomy and bimaxillary surgery (13,15,16) presented with less stability (70–75%) compared to those treated with one-piece LIO.

The limitation of the present review, due to heterogeneity across the studies, we could not do the meta-analysis of included studies. Therefore, no forest plots or funnel plots were constructed. Due to the disparate nature of the studies, only simple descriptive and stratified comparisons are reported. Because of the retrospective design of the included studies, it is difficult to get a firm conclusion.

CONCLUSIONS

AOB treated with one-piece LIO presented with almost 100% of long-term stability compared to those with bimaxillary surgery or multiple-piece LIO and sagittal split osteotomy, which showed stability of 70–75%.

There was no significant difference in long-term stability of corrected AOB and type of malocclusion.

There was no significant difference between extraction and non-extraction methods of treatment and long-term stability of corrected AOB.

Peer-review: Externally peer-reviewed.

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