

## Systematic Review Orthognathic Surgery

# Skeletal stability in orthognathic surgery with the surgery first approach: a systematic review

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**Abstract.** The surgery first approach (SFA) is a therapeutic strategy used in orthognathic surgery that is constantly evolving. With this approach, the pre-surgical orthodontic treatment can be eliminated, the maxilla and the mandible are surgically repositioned into the desired position, and the therapy is ended with a short orthodontic phase. Several studies have reported that the SFA is an acceptable approach, but postoperative stability is unclear. In this study, a systematic review on the SFA was performed. The PubMed, Google Scholar, Scopus, LexisNexis, Web of Science, and Cochrane Library databases were accessed. Studies from which data could be extracted on skeletal stability based on specific cephalometric points were included. The search yielded 2766 publications. Application of the selection criteria resulted in a final group of 14 articles. Five hundred and sixty patients with class III malocclusion underwent orthognathic surgery, 339 with the SFA. Study parameters such as evaluation time points and reference planes varied, making it impossible to perform a meta-analysis. The studies suggest that surgery with the SFA is as stable as surgery with the conventional approach. However, all articles described stability using a penultimate time point of 'after surgery' and not 'after debonding'; hence orthodontic movements and consequent mandibular movements could have influenced cephalometric measurements. Thus, to verify the real stability of the SFA, further research with longer follow-up periods is required, with evaluation at the same time points.

**Key words:** surgery first approach; orthognathic surgery; skeletal stability; systematic review.

Accepted for publication 8 January 2019  
Available online 23 January 2019

The surgery first approach (SFA) is a therapeutic strategy used in orthognathic surgery that is constantly evolving. With this approach, the pre-surgical orthodontic treatment can be eliminated, the maxilla and the mandible are surgically repositioned into the desired position, and the

therapy is ended with a short orthodontic phase. Elimination of the pre-surgical orthodontic treatment differentiates the SFA from the conventional orthognathic surgery approach, which consists of three therapeutic phases: 12–24 months of pre-surgical orthodontic therapy, surgery,

and 5–11 months of post-surgical orthodontic therapy. With the SFA, the patient can immediately appreciate the improvement in facial aesthetics obtained in the surgical phase and can benefit from the reduction in duration of the post-surgical orthodontic therapy and overall duration

of the therapeutic procedure. This approach avoids the progressive aesthetic and oral health deterioration and psychosocial problems associated with the decompensation of the dental elements, which inevitably accompanies pre-surgical orthodontic therapy and affects the patient's perceived quality of life. Due to the absence of pre-surgical orthodontic therapy, close cooperation between the surgeon and the orthodontist is essential to achieve a thorough planning phase.

Several studies in the literature have reported that orthognathic surgery by the SFA is an acceptable and useful approach, but postoperative stability is unclear. The objective of this study was to identify and describe studies examining skeletal stability following the SFA with a minimum of 1 year of follow-up and to analyse horizontal mandibular stability, vertical mandibular stability, horizontal maxillary stability, and vertical maxillary stability.

## Materials and methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement for reporting systematic reviews. The PubMed, Google Scholar, Scopus, LexisNexis, Web of Science, and Cochrane Library databases were considered. The PICOS process was used to develop the search strategy (Table 1). Articles published since 2009 were analysed. No limitations on language of publication were imposed. Boolean operators 'OR' and 'AND' were used to define and connect the search terms.

### Search strategy

The terms used in the PubMed search were: "surgery first"[All Fields] AND ("orthognathic"[All Fields] OR "orthodontics"[All Fields]). The terms used in the Cochrane Library search were: "surgery first" AND ("orthognathic" OR "orthodontic"). The terms used in the Google Scholar search were: "Allintitle:

surgery first orthognathic", "Allintitle: surgery first orthodontics", "Allintitle: surgery first orthodontic". The terms used in the Scopus search were: "surgery first orthognathic", "surgery first orthodontic". The term used in the Web of Science search was: "surgery first orthognathic". The terms used in the LexisNexis search were: "surgery first orthognathic", "surgery first orthodontic".

The references of the selected articles were manually searched for additional papers to add to the review.

### Study selection

The systematic searches were conducted by one author (DS). Study selection was performed by two authors (DS and MT). Titles and abstracts were read and the studies then assessed against the eligibility criteria. The two authors independently assessed the selected studies for eligibility. Articles that satisfied the criteria were selected for full-text reading. In the event of disagreement between the authors, the study was selected for full-text reading. The inclusion criteria were as follows: (1) randomized controlled trials (RCTs), case series, and interventional or observational studies; (2) a study that allowed the extraction of data on skeletal stability based on specific cephalometric points (A-point, B-point, pogonion (Pog), menton (Me)). The following exclusion criteria were applied: (1) case report; (2) review of the literature; (3) patient sample that included patients with craniofacial syndromes or with a history of facial trauma. Studies that satisfied all of these criteria were included. The eligibility of the selected articles was then assessed.

The inter-rater agreement between DS and MT was assessed using the kappa statistic ( $\kappa$ )<sup>1</sup>. Any disagreement between the two authors about the eligibility of a study was discussed with a third author.

### Data extraction

Demographic data, methodological data, and data on stability outcomes were

extracted independently by the same authors. In the event of discrepancies, the article was discussed with the other authors.

### Analysis of methodological quality

The methodological quality and risk of bias of the studies were assessed independently by two investigators. Assessment of the quality of randomized studies was to be done using the Cochrane Collaboration Tool<sup>2</sup>. Assessment of the quality of non-randomized studies was to be done using the Newcastle-Ottawa scale (NOS)<sup>3</sup>. In the event of disagreement between the investigators, a joint decision was made.

### Analysis of surgical stability

The stability of the surgical procedure was assessed by analysing changes in cephalometric values at different time points. Horizontal and vertical distances from certain landmarks (A, B, Pog, Me) to the vertical and horizontal reference planes were considered. The results were expressed in millimetres (mm).

## Results

A flowchart of the systematic review process, describing the steps from the search strategy to final article inclusion, is provided in Fig. 1.

### Search strategy

The search of the major databases was performed on November 29, 2017. A total of 2766 articles were retrieved (PubMed,  $n = 73$ ; Cochrane Library,  $n = 72$ ; Google Scholar,  $n = 80$ ; Scopus,  $n = 824$ ; LexisNexis,  $n = 1352$ ; Web of Science,  $n = 365$ ). After the selection of eligible papers identified in the main search, a manual search of the reference lists of these studies was conducted. This search yielded six additional articles that were ultimately included in the systematic review.

### Study selection

The titles and abstracts of the 2766 articles retrieved in the main search were read independently by the two investigators. Of these, 2658 articles were excluded on the basis of their title and abstract, resulting in the selection of 108 full-text articles. Eight of these papers and six from the manual search were included in the review (Fig. 1)<sup>4-17</sup>. The inter-rater agreement coefficient was  $\kappa = 1$ .

Table 1. PICOS criteria.

Component	Description
Population	Patients requiring orthognathic surgery for the correction of a dentofacial deformity
Intervention	Orthognathic surgery with the surgery first approach
Comparison	Orthognathic surgery with the conventional approach
Outcome	Skeletal stability or relapse
Study design	No case report studies Human interventional or observational studies from which specific data on skeletal stability after orthognathic surgery with the surgery first approach could be extracted, with the aim of evaluating possible skeletal relapse

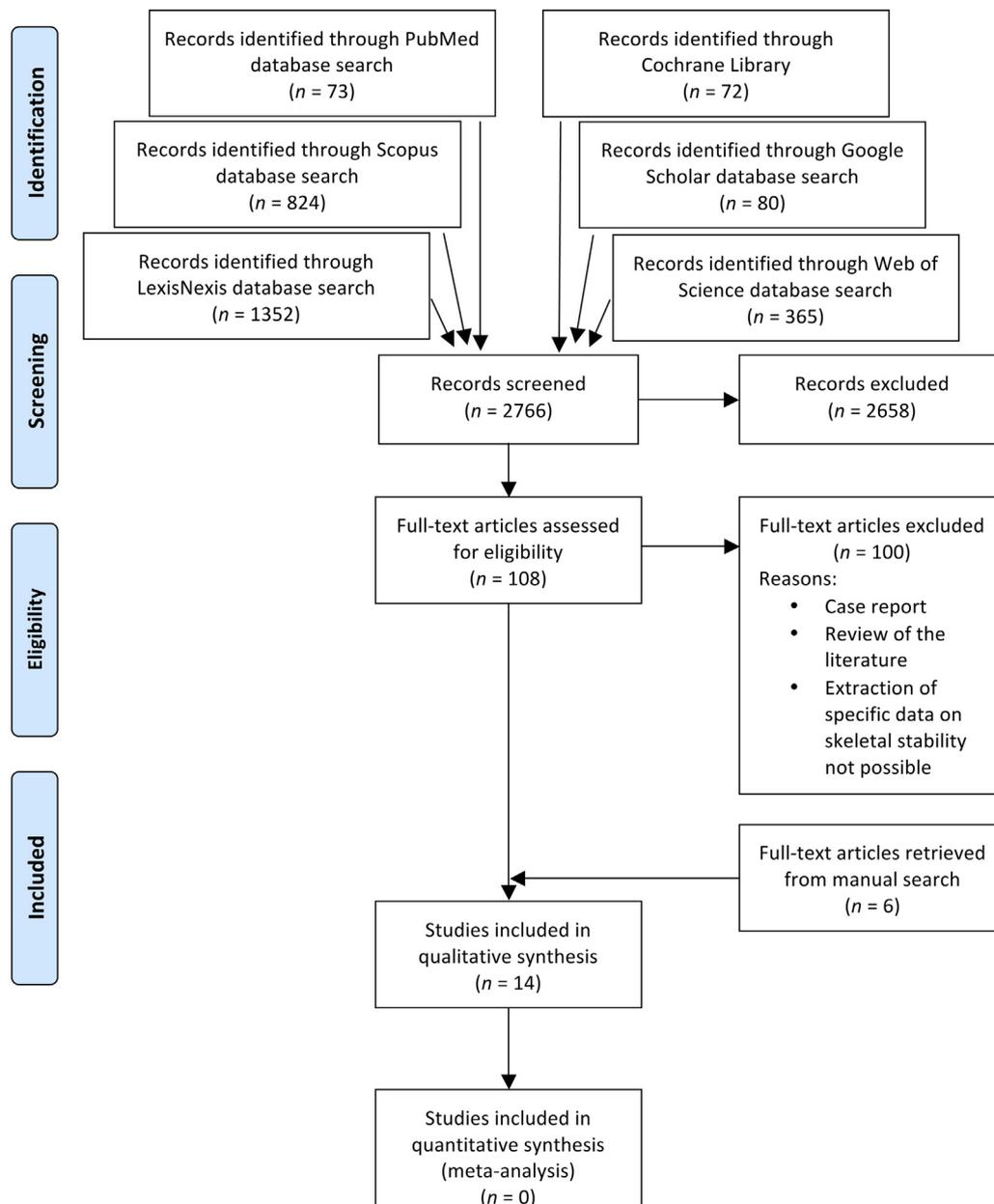


Fig. 1. PRISMA flow diagram of the literature search and selection process.

### Data extraction

The data extracted from the studies are listed in Table 2. The studies included a total of 560 patients who underwent the surgical correction of a dentofacial deformity treated with the SFA ( $n = 339$ ) or the conventional approach (CA;  $n = 221$ ). A total of 394 patients were treated with Le Fort I osteotomy of the maxilla and bilateral sagittal split osteotomy (BSSO)/intraoral vertical ramus osteotomy (IVRO) of the mandible. In addition, 166 patients were treated only with BSSO/IVRO. Approximately 60% of the patients were female. Five studies investigated only orthognathic surgery by the SFA, while the remaining

nine compared the SFA to the CA. These comparative studies were observational studies; no RCTs were identified. Ten studies described bimaxillary surgery: Le Fort I and BSSO/IVRO. Four studies described only mandibular surgery. Three studies described the use of IVRO instead of BSSO for the mandible. The studies were essentially retrospective and were published in the last 8 years (2010–2017).

### Analysis of methodological quality

The methodological quality of the studies was assessed using the NOS, as shown in Table 3. Scores ranged from 4 to 7 out of a

possible 9, representing fair/good quality. Three articles could not be assessed using the NOS because they were not cohort or case-control studies<sup>4,9,13</sup>.

### Analysis of stability

Eleven studies analysed surgical stability in the vertical plane as an outcome measure, while 14 assessed stability in the sagittal plane. All authors used lateral cephalograms for the analysis of the outcomes. The horizontal reference plane was the Frankfort horizontal (FH) plane or sella-nasion (SN) plane rotated clockwise at 7°, and the vertical reference plane was

Table 2. Data extracted from the included studies.

Authors	Journal	Year	Sample size Sex ratio	Class	Type of surgery	Splint after surgery	Internal fixation system
Baek et al. <sup>4</sup>	J Craniofac Surg	2010	<i>n</i> = 11 5 M/6 F	Class III	LFI + BSSO	4 weeks	NR
Liao et al. <sup>5</sup>	Plast Reconstr Surg	2010	<i>n</i> = 33 13 CA: 54% M/46% F 20 SFA: 42% M/58% F	Class III	LFI + BSSO	NR	NR
Ko et al. <sup>6</sup>	J Oral Maxillofac Surg	2011	<i>n</i> = 53 18 SFA: 8 M/10 F 35 CA: 19 M/16 F	Class III	LFI + BSSO	NR	NR
Ko et al. <sup>7</sup>	J Oral Maxillofac Surg	2013	<i>n</i> = 45 19 M/26 F	Class III	LFI + BSSO (genioplasty in 22 subjects)	NR	Miniplates
Kim et al. <sup>8</sup>	Br J Oral Maxillofac Surg	2014	<i>n</i> = 37 20 M/17 F	Class III	LFI + IVRO	2 weeks	Miniplates
Kim et al. <sup>9</sup>	J Oral Maxillofac Surg	2014	<i>n</i> = 61 28 M/33 F 38 CA, 23 SFA	Class III	BSSO	4–6 weeks	Miniplates
Park et al. <sup>10</sup>	Angle Orthod	2014	<i>n</i> = 60 24 M/36 F 36 CA, 24 SFA	Class III	LFI + BSSO	NR	NR
Choi et al. <sup>11</sup>	Ann Plast Surg	2015	<i>n</i> = 56 16 M/40 F 24 CA, 32 SFA	Class III	LFI + BSSO	NR	Miniplates
Park et al. <sup>12</sup>	J Craniofac Surg	2015	<i>n</i> = 38 18 M/20 F 19 CA, 19 SFA	Class III	LFI + BSSO	NR	Miniplates
Kwon et al. <sup>13</sup>	J Oral Maxillofac Surg	2016	<i>n</i> = 27 9 M/18 F	Class III	BSSO	NR	Bicortical screws
Akamatsu et al. <sup>14</sup>	J Plast Surg Hand Surg	2016	<i>n</i> = 38 M/F NR 24 CA, 14 SFA	Class III	BSSO	2 weeks	Miniplates
Ann et al. <sup>15</sup>	Korean J Orthod	2016	<i>n</i> = 24 12 CA, 6 M/6 F 12 SFA, 6 M/6 F	Class III	LFI + IVRO	NR	NR
Choi et al. <sup>16</sup>	J Craniomaxillofac Surg	2016	<i>n</i> = 37 14 M/23 F	Class III	LFI + BSSO ( <i>n</i> = 18) or IVRO ( <i>n</i> = 19)	Wafers for 1–2 weeks after MMF for 2 weeks	BSSO: miniplate IVRO: no
Mah et al. <sup>17</sup>	J Korean Assoc Oral Maxillofac Surg	2017	<i>n</i> = 40 20 M/20 F 20 CA, 20 SFA	Class III	BSSO	“Some patients”	Miniplates

Authors	Time points	Reference plane <sup>a</sup>	Surgical mandibular movements (mm)	Horizontal relapse (mm)	Vertical relapse (mm)
Baek et al. <sup>4</sup>	T0: before treatment T1: after surgery T2: debonding	FH	T1 – T0 Pog ←-9.87	T2 – T1 Pog →2.23 A-point ←-1.18	T2 – T1 NR
Liao et al. <sup>5</sup>	T1: 1 month preop. T2: 1 week postop. T3: debonding	SN7	T2 – T1 Pog ←-10	T3 – T2 A-point: SFA ←-0.6; CA ←-0.5 B-point: SFA →1.6; CA →1.6 Pog: SFA →1.7; CA →1.5	T3 – T2 A-point: SFA ↑0.2; CA 0.0 B-point: SFA ↑2.4; CA ↑0.7 Pog: SFA ↑1.9; CA ↑0.6
Ko et al. <sup>6</sup>	T1: before treatment T2: before surgery T3: 1 month postop. T4: debonding	SN7	T3–T1 (SFA) T3–T2 (CA) Pog: SFA ←-12.6 ↓1.5 CA ←-13.2 ↑2.5 B-point: SFA ←-13.2 ↑0.7 CA ←-13.1 ↑1.9	T4–T3 B-point: SFA →2.1; CA →1.6 A-point: SFA ←-0.2; CA ←-0.4 Pog: SFA →1.8; CA →2.2	T4–T3 B-point: SFA ↓0.8; CA ↑1.4 A-point: SFA ↓0.2; CA ↑0.5 Pog: SFA ↑1.9; CA ↑1.1
Ko et al. <sup>7</sup>	T1: preop. T2: 1 week postop. T3: debonding	SN7	T2–T1 B-point ←-11.19	T3–T2 B-point →1.44	T3–T2 B-point ↑1.65
Kim et al. <sup>8</sup>	T0: preop. T1: 2 days postop. T2: 6 months T3: 12 months <sup>b</sup>	SN7	T1–T0 Pog ←-11.15 Me ↓1.02	T3–T1 Pog →0.63 A-point →0.1	T3–T1 Me ↑2.86 A-point ↑0.3
Kim et al. <sup>9</sup>	T1: 1 month preop. T2: 3 days postop. T3: debonding	FH	T2–T1 B-point: CA ←-8.7 ↑2.7 SFA ←-9.1 ↑3.1 Pog: CA ←-9.3 ↑2.7 SFA ←-9.7 ↑3	T3–T2 B-point: SFA →2.4; CA →1.6 Pog: SFA →2.5; CA →1.6	T3–T2 B-point: SFA ↓1; CA ↓1 Pog: SFA ↓1.4; CA ↓1
Park et al. <sup>10</sup>	T0: initial examination T1: 1 month preop. T2: within 1 month postop. T3: debonding	SN7	T2–T1 (CA) T2–T0 (SFA) B-point: CA ←-10.57 ↓0.22 SFA ←-11.38 ↑3.87 Pog: CA ←-10.38 ↑1.76 SFA ←-10.73 ↑4.26	T3–T2 A-point: CA ←-0.19; SFA ←-0.95 Pog: CA →1.78; SFA →1.65	T3–T2 NR
Choi et al. <sup>11</sup>	T0: preop. T1: 1 week postop. T2: 12 months postop.	NR	T1–T0 “parallel pattern”	T2–T1 “parallel pattern”	T2–T1 At 12–36 months follow-up, relapse not significantly different between groups, except lower AFH ratio, AB to mandible plane, SNB, and IMPA

Park et al. <sup>12</sup>	T0: before treatment T1: 1 month preop. (only CA) T2: postop. immediately after surgery T3: debonding	SN7	T2-T1 (CA) T2-T0 (SFA) B-point: CA ←-8.33 ↑1.80 SFA ←-7.82 ↑1.95 Pog: CA ←-9.34 ↑1.62 SFA ←-8.20 ↑2.18	T3-T2 A-point: CA ←-0.4; SFA →0.6 B-point: CA →1.3; SFA →1.8 Pog: CA →1.4; SFA →2	T3-T2 A-point: CA ↓0.63; SFA ↓0.02 B-point: CA ↑0.31; SFA ↑0.36 Pog: Ca ↑1.69; SFA ↑0.52
Kwon et al. <sup>13</sup>	T1: preop. T2: 1 month postop. T3: 6 months	SN7	T2-T1 B-point ←-6.8 ↑2.3 Pog ←-5.5 ↑2.4	T3-T2 B-point →0.54 Pog →0.91	T3-T2 B-point ↑1.24 Pog ↑0.61
Akamatsu et al. <sup>14</sup>	T0: 2 weeks preop. T1: 2 weeks postop. T2 (CA): 1 year after T2 (SFA): debonding	SN7	T1-T0 B-point: CA ←-6.29 ↑2.13 SF ←-9.73 ↑1.26 Pog: CA ←-5.82 ↑1.85 SFA ←-8.78 ↑1.76	T2-T1 B-point: CA →0.55; SFA →0.99 Pog: CA →0.9; SFA →0.86	T2-T1 B-point: CA ↑0.45; SFA ↓0.87 Pog: CA ↑0.14; SFA ↓1.59
Ann et al. <sup>15</sup>	T0: preop. T1: 1 month postop. T2: 1 year postop.	FH	T1-T0 B-point: CA ←-11.26 ↑1.48 SFA ←-12.16 ↑1.17 Pog: CA ←-10.04 ↑3.25 SFA ←-13.36 ↑2.80	T2-T1 A-point: CA ←-0.26; SFA ←-0.15 B-point: CA →1.8; SFA →2.1 Pog: CA →1.6; SFA →2	T2-T1 A-point: CA ↑0.6; SFA ↑0.3 B-point: CA ↑0.8; SFA ↑1.9 Pog: Ca ↑0.1; SFA ↑1.6
Choi et al. <sup>16</sup>	T1: 1 month preop. T2: 2 weeks postop. T3: 12 months after	SN7	T2-T1 B-point: BSSO ←-9.3 ↑3.2 IVRO ←-11.5 ↑0.1	T3-T2 B-point: BSSO →2.2; IVRO →0.6 A-point: BSSO ←-0.2; IVRO ←-0.7	T3-T2 B-point: BSSO ↑3; IVRO ↑1.9 A-point: BSSO ↓0.4; IVRO ↑0.3
Mah et al. <sup>17</sup>	T0: preop. T1: 2/4 weeks postop. T2: 1 year postop. or at debonding	FH	T1-T0 B-point: CA ←-10.26 ↓0.64 SFA ←-10.58 ↓0.89 Pog: CA ←-11.51 ↓1.02 SFA ←-11.82 ↓1.24	T2-T1 B-point: CA →2.23; SFA →3.49 Pog: CA →2.54; SFA →4.11	T2-T1 B-point: CA ↑0.87; SFA ↑1.78 Pog: CA ↑1.18; SFA ↑2.4

AB, A-point-B-point; AFH, anterior facial height; BSSO, bilateral sagittal split osteotomy; CA, conventional approach; F, female; FH, Frankfort horizontal plane; IMPA, incisor mandibular plane angle; IVRO, intraoral vertical ramus osteotomy; LFI, Le Fort I; M, male; Me, menton; MMF, maxillomandibular fixation; NR, not reported; Pog, pogonion; postop., postoperative; preop., preoperative; SFA, surgery first approach; SN7, SN plane rotated clockwise at 7°; SNB, sella-nasion-B-point angle.

<sup>a</sup> Horizontal reference plane.

<sup>b</sup> The mean total duration of treatment including postoperative orthodontics was 14 months.

Table 3. Methodological quality of the studies included—Newcastle–Ottawa scale.

Study	Score <sup>a</sup>
Baek et al., 2010 <sup>4</sup>	NA
Liao et al., 2010 <sup>5</sup>	6
Ko et al., 2011 <sup>6</sup>	5
Ko et al., 2013 <sup>7</sup>	7
Kim et al., 2014 <sup>8</sup>	7
Kim et al., 2014 <sup>9</sup>	NA
Park et al., 2014 <sup>10</sup>	4
Choi et al., 2015 <sup>11</sup>	7
Park et al., 2015 <sup>12</sup>	5
Kwon et al., 2016 <sup>13</sup>	NA
Akamatsu et al., 2016 <sup>14</sup>	6
Ann et al., 2016 <sup>15</sup>	5
Choi et al., 2016 <sup>16</sup>	7
Mah et al., 2017 <sup>17</sup>	6

NA, not applicable.

<sup>a</sup>Maximum score = 9; range for low quality = 0–3; range for medium quality = 4–6; range for high quality = 7–9.

a plane perpendicular to the horizontal reference plane passing through sella (S) or nasion (N) (Figs. 2–6).

#### Horizontal mandibular relapse

In the analysis of the distances between B-point/Pog and the vertical reference plane at the last time point (which was debonding at either 6 months after surgery or 12 months after surgery, depending on the individual study) and at the first time point after surgery, the following results were found: all studies showed that Pog and/or B-point moved forward in the CA and the

SFA. Eight studies compared post-surgical movements in the SFA and the CA: in five articles, the difference between the SFA and the CA was found to be  $\leq 0.5$  mm (SFA > CA)<sup>5,6,10,14,15</sup>; in two articles, the difference between the SFA and the CA was found to be 0.5–1 mm (SFA > CA)<sup>9,12</sup>; in one article, the difference between the SFA and the CA was found to be  $> 1$  mm (SFA > CA)<sup>17</sup>.

#### Vertical mandibular relapse

In the analysis of the distances between B-point/Pog/Me and the horizontal reference plane at the last time point (which was debonding at either 6 months after surgery or 12 months after surgery, depending on the individual study) and at the first time point after surgery, the following results were found: eight articles showed mandibular upward movement<sup>5,7,8,12,13,15–17</sup>; four of these compared the SFA to the CA, and the difference was always  $> 1$  mm. One article reported downward movement at B-point in both the CA and SFA groups, with no difference between the approaches<sup>9</sup>. One article showed upward movement of Pog and B-point in the CA group and downward movement in the SFA group<sup>14</sup>. One article reported upward movement of Pog in the CA and SFA groups, with a difference of 0.8 mm between the groups (greater in the SFA group), and upward movement of B-point in the CA group and downward movement in the SFA group<sup>6</sup>.

#### Horizontal maxillary relapse

In the analysis of the distances between A-point and the vertical reference plane at the last time point (which was debonding at either 6 months after surgery or 12 months after surgery, depending on the individual study) and at the first time point after surgery, the following results were found: eight articles evaluated horizontal maxillary relapse, which was always  $< 1$  mm<sup>5,6,8,10,12,15,16</sup>, except in one study in which it was 1.18 mm<sup>4</sup>. Three studies analysed only the SFA: two showed backward movement of A-point<sup>4,16</sup> and one showed forward movement<sup>8</sup>. Regarding the five articles that compared the CA and the SFA, four showed backward movement with both approaches<sup>5,6,10,15</sup>, and the other showed backward movement in the CA group and forward movement in the SFA group<sup>12</sup>.

#### Vertical maxillary relapse

In the analysis of the distances between A-point and the horizontal reference plane at the last time point (which was debonding at either 6 months after surgery or 12 months after surgery, depending on the individual study) and at the first time point after surgery, the following results were found: six articles analysed vertical maxillary relapse and the movement was always  $< 1$  mm. One article that analysed only the SFA showed upward relapse<sup>8</sup>. One article showed the same upward relapse in both the SFA and CA groups<sup>15</sup>. One article showed the same downward relapse in both the SFA and CA groups<sup>12</sup>. One article showed downward relapse in the SFA group and upward relapse in the CA group<sup>6</sup>. One article showed no vertical relapse in the CA group, but upward relapse in the SFA group<sup>5</sup>. Finally, one article showed upward relapse for the SFA with the IVRO technique and downward relapse for the SFA with the BSSO technique<sup>16</sup>.

#### Discussion

The search of the major databases was performed on November 29, 2017 and retrieved a total of 2766 articles. One hundred and eight full texts were assessed for eligibility. Finally eight of these papers and six from the manual search were included in the review (Fig. 1).

The studies included a total of 560 patients who underwent the SFA or CA to correct a dentofacial deformity. A total of 394 patients were treated with Le Fort I osteotomy of the maxilla and BSSO/

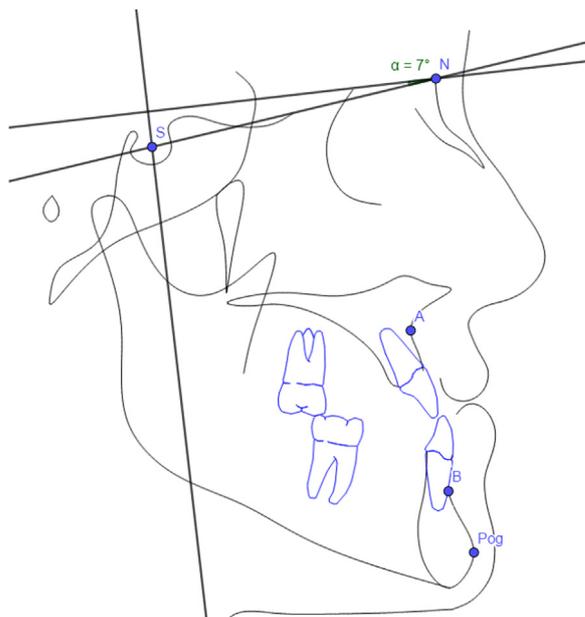


Fig. 2. Horizontal reference plane: SN7 passing through nasion (N). Vertical reference plane: perpendicular to the horizontal plane passing through sella (S).

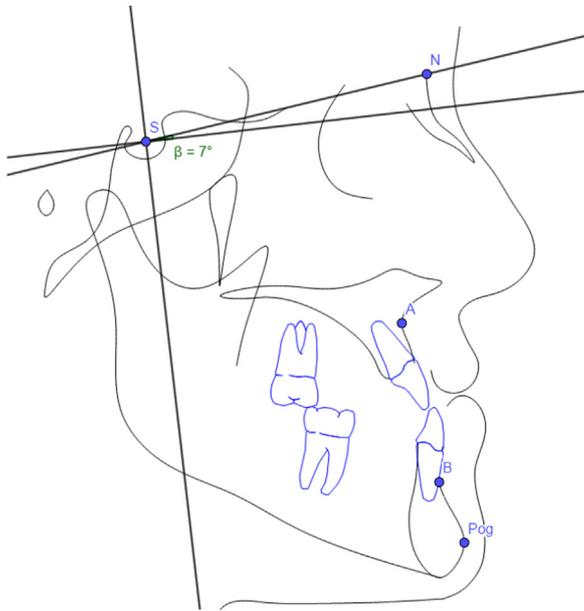


Fig. 3. Horizontal reference plane: SN7 passing through sella (S). Vertical reference plane: perpendicular to the horizontal plane passing through S.

IVRO osteotomy of the mandible, while 166 patients were treated only with BSSO/IVRO. There were more female than male patients (approximate male to female ratio, 1:1.3). Five studies investigated orthognathic surgery only by the SFA, while the remaining nine compared the SFA to the CA. The comparative studies were all observational studies; none was a RCT. Ten studies described

bimaxillary surgery of Le Fort I and BSSO/IVRO and four described only mandibular surgery. IVRO instead of BSSO for the mandible was described in three studies. The studies were generally retrospective and were published during the years 2010–2017.

All of the articles considered in this review analysed patients with class III dentoskeletal anomalies.

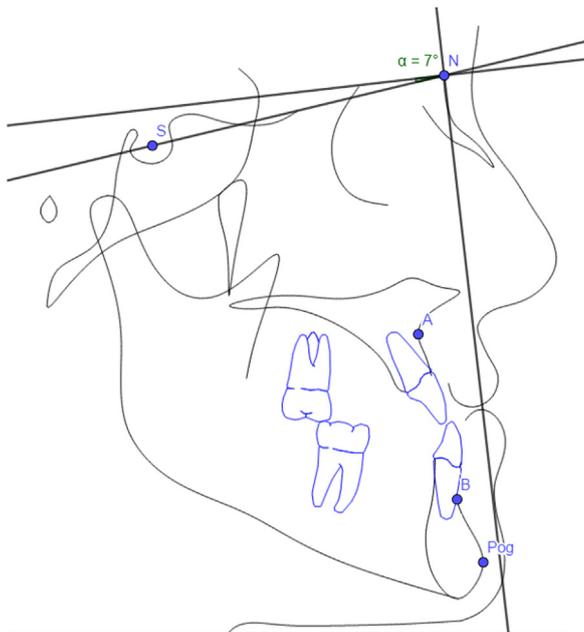


Fig. 4. Horizontal reference plane: SN7 passing through nasion (N). Vertical reference plane: perpendicular to the horizontal plane passing through N.

The authors of the studies considered different parameters to define stability after the SFA: evaluation time points and reference planes varied, making it impossible to perform a meta-analysis. In the articles reviewed, the FH and SN7 planes were used as the horizontal reference planes. The SN plane is useful for evaluating the craniofacial relationship, while the FH plane is appropriate for assessing the face<sup>18</sup>; however, because of the low reproducibility and accuracy of porion and orbitale, which are reference points of the FH plane, the SN7 plane is more often used<sup>19</sup>.

Eleven studies analysed surgical stability in the vertical plane as an outcome measure, while 14 assessed stability in the sagittal plane. All authors used lateral cephalograms for the analysis of the outcomes. The horizontal reference plane was the FH plane or SN plane rotated clockwise at 7°, and the vertical reference plane was a plane perpendicular to the horizontal reference plane passing through S or N.

In the analysis of the distances between B/Pog and the vertical reference plane at the last time point and at the first time point after surgery, it was found that all articles reported forward movement of Pog and/or B-point in both the CA and SFA groups. Of the eight studies comparing post-surgical movements between the SFA group and the CA group, five reported a difference between the SFA and CA groups of  $\leq 0.5$  mm (SFA > CA)<sup>5,6,10,14,15</sup>, two articles reported a difference between the SFA and CA groups of 0.5–1 mm (SFA > CA)<sup>9,12</sup>, and one reported a difference between the SFA and CA groups of >1 mm (SFA > CA)<sup>17</sup>.

In the analysis of the distances between B/Pog/Me and the horizontal reference plane at the last time point and at the first time point after surgery, it was found that eight articles reported mandibular upward movement<sup>5,7,8,12,13,15–17</sup>. Four of these compared the SFA group to the CA group, and the difference was always >1 mm. Furthermore, one article showed downward movement at B-point in both the CA and the SFA groups, with no difference between approaches<sup>9</sup>, one article showed Pog and B-point upward movement in the CA group and downward movement in the SFA group<sup>14</sup>, and one article showed upward movement of Pog in the CA and SFA groups with a difference of 0.8 mm (SFA > CA) and upward movement of B-point in the CA group and downward movement in the SFA group<sup>6</sup>.

In 2012, Proffit et al.<sup>20</sup> stated that it is important to differentiate post-surgical stability (changes in the first post-surgical

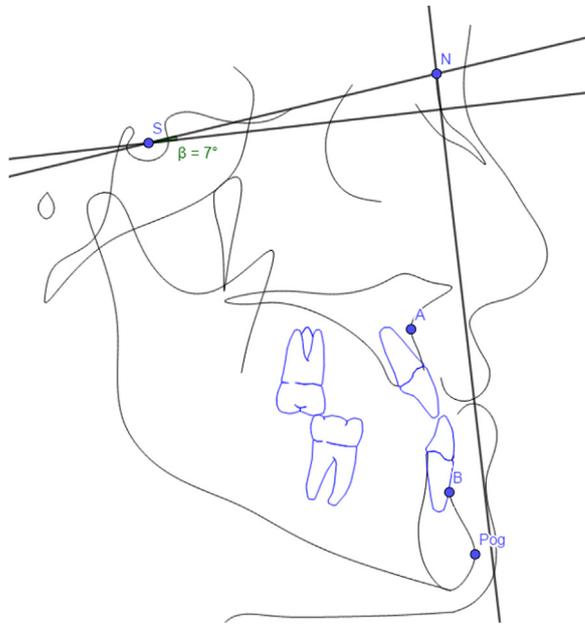


Fig. 5. Horizontal reference plane: SN7 passing through sella (S). Vertical reference plane: perpendicular to the horizontal plane passing through nasion (N).

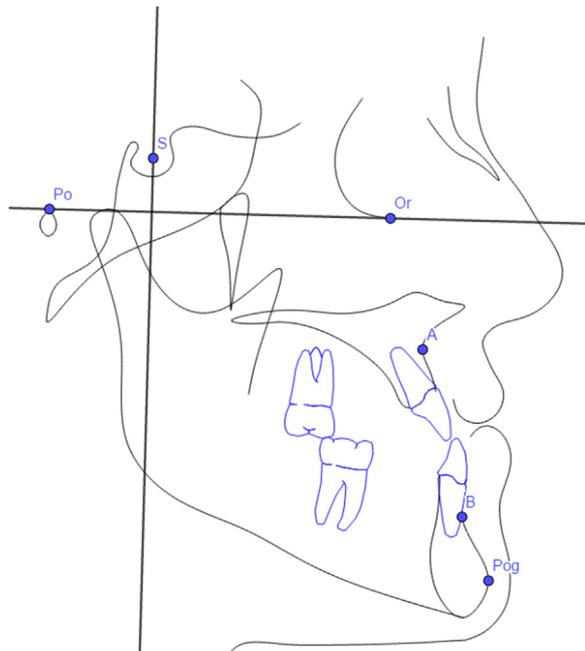


Fig. 6. Horizontal reference plane: Frankfort plane. Vertical reference plane: perpendicular to the horizontal plane passing through sella (S).

year, which relate directly to surgical healing, post-surgical orthodontics, and short-term physiological adaptation) from post-treatment stability (changes beyond 1 year post-surgery, which relate to long-term adaptation and, for some patients, to post-treatment growth). However, the first post-surgical year differs greatly between the two approaches. In the CA, post-surgical orthodontic treatment should be only

a finalization phase, while in the SFA, all orthodontic movements occur in this phase.

This review found that the SFA showed higher mean mandibular horizontal relapse compared to the CA, but the difference was always <1 mm, except in one article, which reported a mean difference of 1.26 mm for the B-point and 1.57 mm for Pog<sup>17</sup>. Most of the reviewed studies

reported a forward and upward movement of the mandible, presumably due to counterclockwise mandibular rotation around the condylar head.

As reported by Ko et al.<sup>6</sup>, the more vertical reduction in the SFA group compared to the CA group is due to a more vertical bite settling after surgery, especially in cases with a severe occlusal interference between arches.

Akamatsu et al. reported a significantly greater postoperative vertical relapse in the SFA group compared with the CA group; however, in contrast to all of the other studies reviewed, they found a downward mandibular movement<sup>14</sup>. They concluded that the downward movement was due to the stronger and more intensive use of intermaxillary elastics in the SFA group than in the CA group. These postoperative intermaxillary elastics may lead to vertical skeletal relapse because of their slight tendency to extrude teeth. Hence, they suggested the introduction of skeletal screws in their SFA protocol.

The present authors consider that the mandibular counterclockwise rotation in the SFA can result from the following: (1) the normal consequence of the occlusion settling after surgery, which should be considered and budgeted for during the planning phase; (2) the effect of intraoperative malpositioning (backward push) of the condyles from their initial position, with immediate skeletal relapse when the condyles return to their preoperative position.

Immediately after orthognathic surgery without pre-surgical orthodontic treatment, the mandible tends to show an open bite because of dental interference, in contrast to the orthodontic-first approach, in which dental interference is previously removed by pre-surgical orthodontic treatment. In the present authors' experience, the open bite decreases when the orthodontist starts post-surgical orthodontic treatment. This is not relapse but an expected movement, since the evaluation of stability is based on parameters calculated before the end of the post-surgical orthodontic treatment.

There is a relationship between the amount of mandibular setback and post-surgical stability (all things being equal, the greater the setback, the greater the amount of post-surgical change in the position of the mandible)<sup>21</sup>. It can be stated, therefore, that for patients requiring a large change in jaw relationship, restricting the amount of mandibular setback by simultaneously advancing the maxilla contributes to stability<sup>20</sup>.

In the analysis of the distances between A-point and the vertical reference plane at the last time point and at the first time point after surgery, it was found that eight articles evaluated horizontal maxillary relapse and this was always <1 mm, with the exception of one study in which this was 1.18 mm. Three studies analysed only the SFA, with two showing backward movement at A-point<sup>4,16</sup> and one article showing forward movement at A-point<sup>8</sup>. Of the five articles that compared the CA to the SFA, four show backward movement with both approaches<sup>3,6,10,15</sup> and one showed backward movement in the CA group and forward movement in the SFA group<sup>12</sup>.

In the analysis of the distances between A-point and the horizontal reference plane at the last time point and at the first time point after surgery, six articles analysing vertical maxillary relapse were identified, and the movement was always <1 mm. One article that analysed only the SFA reported upward relapse<sup>8</sup>. One article reported the same upward relapse in both the SFA and CA groups<sup>15</sup>, one reported the same downward relapse in both the SFA and CA groups<sup>12</sup>, one reported downward relapse in the SFA group and upward relapse in the CA group<sup>6</sup>, one reported no vertical relapse in the CA group and upward relapse in the SFA group<sup>5</sup>, and one reported upward relapse in the SFA group with the IVRO technique and downward relapse in the SFA group with the BSSO technique<sup>16</sup>.

All of the articles reviewed reported that maxillary surgical repositioning is relatively stable in orthognathic surgery with the SFA: the vertical and the horizontal relapse was always <1 mm, except in one article in which the horizontal relapse was 1.18 mm.

Different studies on stability after a combination of maxillary advancement and mandibular setback in orthognathic surgery with the CA have stated the same conclusions<sup>20</sup>: the maxillary advancement component is relatively stable, while larger mandibular changes occur. Jakobsone et al. evaluated the stability of bimaxillary surgery at the 3-year recall and noted that mandibular stability was not as good as maxillary stability; they suggested that the major risk factors for mandibular relapse were a large setback and inferior repositioning of the posterior maxilla<sup>22</sup>. None of these investigators looked at changes in mandibular ramus inclination as a potential relapse factor.

In conventional orthognathic procedures, the variation in the force arms of the closing and opening muscle groups of

the jaw may cause difficulties in the establishment of optimal occlusion<sup>23</sup>. Arpornmaeklong et al. stated that stable occlusal interdigitation is necessary for postoperative healing and stability<sup>24</sup>. The problem of occlusal stability is even more significant when the SFA is used, as the postoperative occlusion is by definition unstable, so elastic bands are required to avoid early postoperative malocclusion due to uncontrolled muscular activity.

Schendel and Epker in 1980 distinguished between the early relapse that occurs in the first few months after surgery and late relapse<sup>25</sup>. The aetiology of relapse is multifactorial and factors affecting this include the proper seating of the condyles, the amount of surgical movement, the influence of the soft tissues, the remaining growth potential and remodelling, and the skill of the surgeon and the orthodontist. Sex does not seem to be relevant in relapse<sup>26</sup>. Possible sites for relapse include the osteotomy sites, through inter-segmental movement, and the temporomandibular joint, through condylar distraction, rotation of the ramus (proximal) segment, and morphological changes in the condyle<sup>26</sup>. However, the actual cause of relapse after surgery remains unclear<sup>27-30</sup>.

There is controversy in the literature regarding the need for positioning appliances. Gerressen et al. stated that the importance of condylar position is overestimated<sup>31</sup>. They believe that the use of a positioning appliance does not lead to an accurate reproduction of the preoperative condylar position, with no improvement in skeletal stability. However, other authors have asserted that controlling the position of the proximal segment with the use of a positioning appliance device is the most important factor in post-treatment stability<sup>32</sup>.

With regard to skeletal stability, bicortical screws seem to show slightly better results than miniplates in the short term. Nevertheless, several studies have reported better long-term stability in patients treated with miniplates compared to bicortical screws<sup>26</sup>.

The SFA in orthognathic surgery is associated with early positional changes in the mandible. These changes should not always be considered as an index of early relapse since postoperative mandibular position can change as a consequence of post-surgical orthodontic treatment. Early positional changes of the mandible with the SFA do not represent real relapse and should be distinguished from malpositioning due to the inaccuracy of planning, surgical treatment, or postoperative ortho-

odontic treatment, which can lead to relapse and malocclusion.

In conclusion, studies in the literature suggest that orthognathic surgery with the SFA is as stable and predictable as surgery with the CA. Unfortunately, all articles describe stability with a penultimate time point of 'after surgery' and not 'after debonding'; during this post-surgery period, orthodontic treatment is still ongoing, and orthodontic movements and consequent mandibular movements could influence cephalometric measurements of stability. Therefore, to verify the real stability of orthognathic surgery with the SFA, further research with the same reference planes, longer follow-up periods, and the same evaluation time points is required. Furthermore, none of the articles reviewed described class II dentoskeletal anomalies, so additional research in this field is required.

### Limitations

This review is subject to the following limitations: no RCTs on the SFA were retrieved in the literature search; all of the articles considered in this review analysed patients with class III dentoskeletal anomalies (one article in the literature reported a case with class II dentoskeletal anomalies, but this was a case report and was therefore excluded); different parameters were considered by the authors to define stability after the SFA: time points and reference planes varied, making it impossible to perform a meta-analysis.

### Funding

No funding. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### Competing interests

No competing interests.

### Ethical approval

Not required.

### Patient consent

Not required.

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