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## Surgical Occlusion Setup in Orthognathic Surgery Using Surgery-First Approach for Skeletal Class III Deformity: A Systematic Review

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## Abstract

**Objective:** Surgery-first orthognathic surgery is increasing in popularity because of reduced treatment time, efficient tooth decompensation, and early improvement in facial esthetics. However, it remains difficult due to the surgical occlusion setup. We systematically reviewed the literature in order to determine the guidelines used for surgical occlusion setup in orthognathic-first surgery for skeletal Class III deformity. **Material and Methods:** The literature was searched using PubMed, Medline (Ovid), Cochrane Library, Web of Science and Google Scholar databases from January 1931 to June 2017. We limited the search to publications in English. Two independent investigators used specific inclusion and exclusion criteria to extract and analyze the data. Study quality was assessed objectively. **Results:** Of 288 papers retrieved, 13 met the inclusion and exclusion criteria. All studies were of low quality. The occlusion was suggested to be set as Class I, II or III molar relationship, deep bite or posterior open bite, little or no posterior crossbite or no complete posterior dental or skeletal crossbite, and stable posterior occlusion or at least three occlusal stops. **Conclusions:** The results should be interpreted with caution due to the low number, poor quality, and heterogeneity of the included studies. Due to contradictory results and poor study quality, the scientific evidence is too weak to show the guidelines of surgical occlusion setup in surgery-first orthognathic surgery for skeletal Class III deformity. Further quantitative studies are required.

## Keywords

orthognathic surgery; skeletal Class III; surgery-first approach; surgical occlusion.

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## Cover Page Footnote

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# SURGICAL OCCLUSION SETUP IN ORTHOGNATHIC SURGERY USING SURGERY-FIRST APPROACH FOR SKELETAL CLASS III DEFORMITY: A SYSTEMATIC REVIEW

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**Conclusions:** The results should be interpreted with caution due to the low number, poor quality, and heterogeneity of the included studies. Due to contradictory results and poor study quality, the scientific evidence is too weak to show the guidelines of surgical occlusion setup in surgery-first orthognathic surgery for skeletal Class III deformity. Further quantitative studies are required. (*Taiwanese Journal of Orthodontics*. 30(2): 82-91, 2018)

Keywords: orthognathic surgery; skeletal Class III; surgery-first approach; surgical occlusion.

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## INTRODUCTION

Before the 1960s, most orthognathic surgeries were performed either without orthodontic treatment or before any orthodontic treatment. As the stability of the results improved and satisfaction with the post-treatment outcomes increased the three stages of classic surgical orthodontic treatment became popular.<sup>1</sup> The 3-stage approach requires a variable length of pre-surgical orthodontic preparation to decompensate the malocclusion. Pre-surgical preparation is followed by surgical correction of the skeletal discrepancy and a relatively short period of post-surgical orthodontic treatment, which allows for detailing and finishing of the occlusion. Pre-surgical orthodontics typically includes dental alignment, incisor decompensation, arch leveling and coordination, and usually requires 15 to 24 months.<sup>2,3</sup> However, pre-surgical orthodontics exacerbates facial esthetics and dental function, and causes patients a significant amount of discomfort prior to surgical treatment.<sup>2</sup> One study found that one third of patients rated the orthodontic treatment as the worst part of their orthognathic treatment owing to the appliances' visibility and discomfort, and the length of treatment.<sup>4</sup>

A new approach to orthognathic surgery is called "surgery-first," which eliminates the pre-surgical orthodontic phase, avoiding the longer treatment time and transitional detriment to facial esthetics and dental function associated with pre-surgical orthodontic treatment.<sup>5-7</sup> Surgery-first orthognathic surgery is increasing in popularity because of several advantages: reduced treatment time, efficient tooth decompensation, and early improvement in facial esthetics, especially in Class III malocclusion.<sup>5-10</sup> These advantages positively influence a patients' global satisfaction with treatment. The optimal esthetic and functional results, significant reduction in total treatment time, and high patient satisfaction have led to the postulation that the surgery-first approach may represent a reasonable and cost-effective

method to manage skeletal deformity, and has the potential to become a standard approach of orthognathic surgery in the future.<sup>5,8</sup>

However, the most difficult step for the surgery-first approach is the setup of the transitional occlusion at the time of surgery (i.e., surgical occlusion). Because dental alignment, arch leveling and coordination, and incisor decompensation are deferred, a major consideration for the surgical occlusion setup with the surgery-first approach is to compensate for the space required for the dental movement. This is similar to the process that the orthodontist performs to correct any malocclusion of skeletal Class I, because skeletal deformity is corrected from the start. Accurate surgical occlusion setup is important to avoid severe postoperative occlusal instability, incomplete or excessive skeletal correction, or skeletal asymmetry. However, a systematic review of surgical occlusion setups used with the surgery-first approach has not been undertaken. The aims of this study were to conduct a systematic review of the literature on orthognathic surgery and to identify guidelines for surgical occlusion setup in patients who had undergone surgery-first orthognathic surgery for Class III malocclusion.

## MATERIAL AND METHODS

### Eligibility criteria

The following inclusion criteria were applied for the literature review: (1) human patients; (2) patients who underwent surgery-first orthognathic surgery for correction of skeletal Class III deformity; (3) at least one guideline for surgical occlusion setup was described; and (4) the study design was case report, case series, case-control study, cohort study, or randomized controlled trial. The exclusion criteria were as follows: (1) syndromic patients; (2) congenital deformity; (3) unrelated disease (i.e., oncologic or traumatic cases); (4) experts' opinions or suggestion; or (5) reviews.

## Literature Search

To identify relevant publications, we searched the following electronic databases: PubMed, Medline (Ovid), Cochrane Library, Web of Science, and Google Scholar databases from January 1931 to June 2017 using the MeSH terms “orthognathic surgery” or “jaw surgery” and “surgical occlusion” or “transitional occlusion” or “occlusion,” or “three-point contacts,” and “surgery first” or “orthognathic first” and “mandible prognathism” or “Class III malocclusion.” We limited the search to publications in English. Hand searches were undertaken to find additional relevant published material that might have been missed in the electronic searches.

A 3-stage screening (titles, abstract, and full text) was carried out independently and in duplicate by two researchers (S.H.L and Y.F.L). The title and abstract of each retrieved article were first independently screened by the two researchers for reports of surgical occlusion setup in skeletal Class III deformity. After reviewing the abstract only, we classified articles as included, excluded, or unclear. Differences about which articles to include or exclude were resolved by consensus. For articles classified as included or unclear, we then obtained the full papers. The full papers were reviewed independently by both authors, and final inclusion was based on the inclusion and exclusion criteria. Inter-researcher agreement on study selection was assessed by Cohen’s kappa.

## Data Items and Collection

Articles were independently analyzed to extract the following data: author, year of publication, country, study design, type of deformity, number of patients, type of surgery, type of orthodontic mechanism, and guideline of surgical occlusion setup. Inter-reviewer agreement on data extraction was evaluated by Cohen’s kappa.

The quality of each paper (i.e., the soundness of its methods) was also independently evaluated according to PRISMA<sup>11</sup> and MOOSE<sup>12</sup> statements with five criteria:

random sampling, subject selection described, valid methods, confounding factors considered, and adequate statistics provided. The quality of each article was categorized as low ( $\leq 3$  criteria fulfilled), moderate (4 criteria fulfilled), or high (5 criteria fulfilled). Data were extracted and the quality of each paper was assessed independently by both authors without blinding. Conflicts between authors were resolved by discussing each paper to reach a consensus. Inter-reviewer agreement on quality assessment was evaluated by Cohen’s kappa.

## RESULTS

### Study selection and characteristics

After exclusion of duplicate articles, the database search resulted in 86 articles. Hand searches of the bibliographies of the selected articles and relevant reviews added an additional 22 articles. Of these, only 13 fulfilled the inclusion and exclusion criteria and thus were included in this systematic review (Fig 1).<sup>5-8,10,13-20</sup> The kappa scores before reconciliation for the selection, data extraction, and quality evaluation procedures were 0.846, 0.947, and 0.871, respectively, which indicated almost perfect agreement.

The characteristics of the 13 studies included in the review are presented in Table 1. Seven studies were case reports, three were case series, and three were retrospective cohort studies. Eleven studies<sup>5-8,13-17,19,20</sup> reported occlusion setup for Class III deformity, and the other two studies<sup>10,18</sup> reported occlusion setup for a mixed sample of various malocclusion. Five studies adopted 1-jaw (mandibular) surgery,<sup>5,6,16,17,20</sup> five studies adopted 2-jaw surgery<sup>7,8,13-15</sup> and three studies adopted 1- and 2-jaw surgery.<sup>10,18,19</sup> All but one<sup>15</sup> studies used rigid fixation.

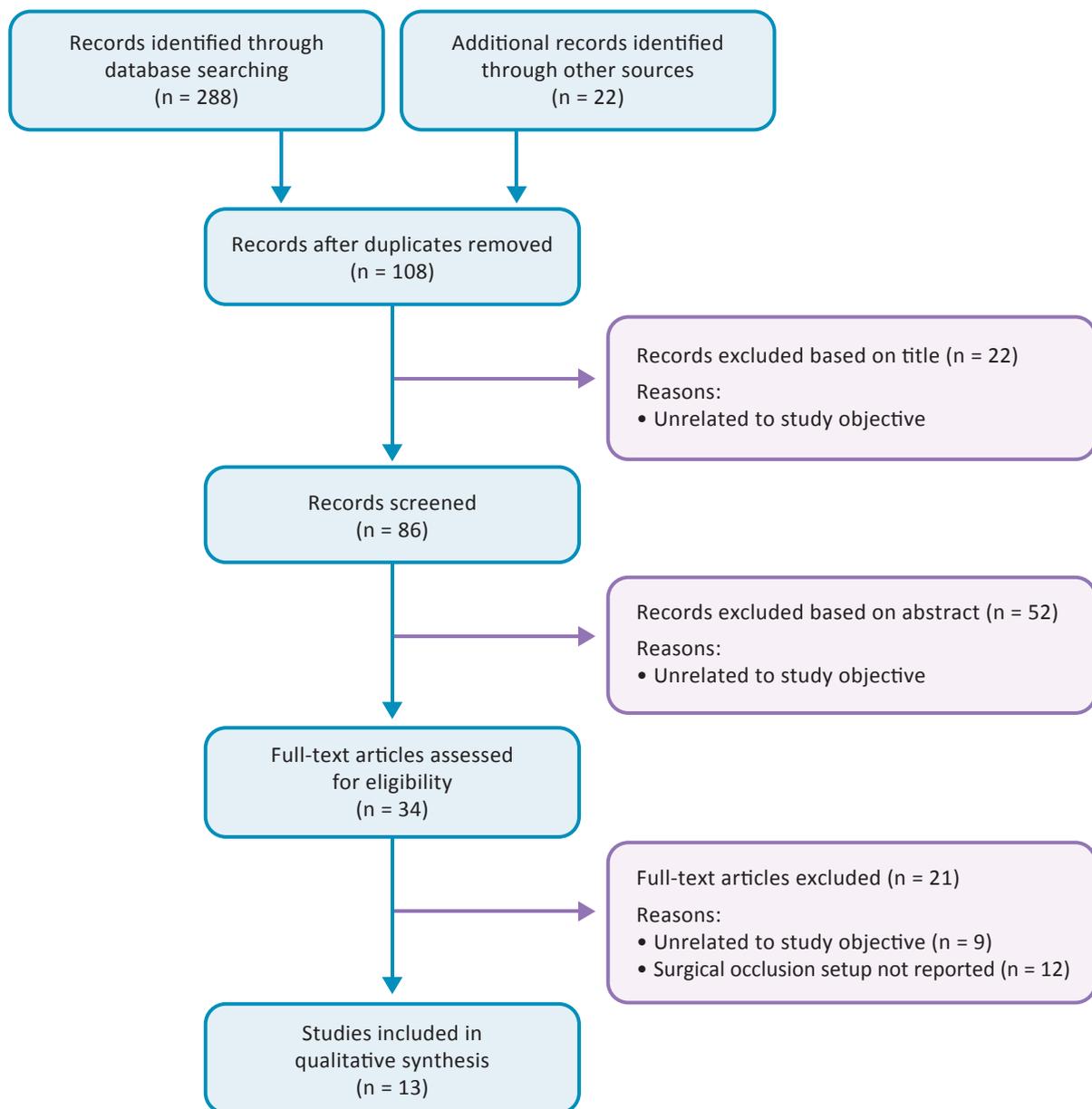
In the 13 studies, the occlusion was suggested to set as Class I, II or III molar relationship in the sagittal dimension,<sup>5-8,10,14-16,18</sup> deep bite or posterior open bite in the vertical dimension,<sup>8,19</sup> little or no posterior crossbite<sup>10,13,18,19</sup>

or no complete posterior dental<sup>10</sup> or skeletal crossbite<sup>8</sup> in the transverse dimension, and stable posterior occlusion<sup>5-7,14</sup> or at least three occlusal stops.<sup>13,17,19,20</sup>

However, none of the studies provided quantitative data of the surgical occlusion.

### Study Quality Analysis

The criteria examined in the 13 studies and the results of quality assessment according to a checklist are shown in Table 2. The studies reviewed had common methodological problems, and the all were categorized as having a low degree of quality.



**Figure 1.** Flow diagram of the literature search.

**Table 1.** Summary of data extracted from included studies (N=13)

No.	Author, year	Country	Study design	Deformity (No. of patients)	Approach (No. of patients)	Surgery	Orthodontic Mechanism	Guideline of Surgical Occlusion Setup
1	Nagasaka et al., <sup>5</sup> 2009	Japan	Case report	Class III (1)	SF (1)	B	<ol style="list-style-type: none"> <li>1. SAS for distalization of maxillary dentition</li> <li>2. Occlusal splint for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. Class II molar (full cusp)</li> <li>2. Anterior open bite</li> <li>3. Stable posterior occlusion</li> </ol>
2	Villegas et al., <sup>6</sup> 2010	Columbia	Case report	Class III facial symmetry (1)	SF (1)	B + G	<ol style="list-style-type: none"> <li>1. SAS for distalization of maxillary dentition</li> </ol>	<ol style="list-style-type: none"> <li>1. Class II molar (cusp-to-cusp)</li> <li>2. Stable posterior occlusion</li> </ol>
3	Baek et al., <sup>13</sup> 2010	Korea	Retrospective case series	Class III (11)	SF (11)	LF + B	<ol style="list-style-type: none"> <li>1. Clockwise rotation of the palatal plane for upper incisor decompensation</li> <li>2. Miniplates or miniscrews to control upper incisor angle</li> <li>3. Occlusal splint for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. At least 3 occlusal stops</li> <li>2. Little or no transverse discrepancy</li> </ol>
4	Yu et al., <sup>7</sup> 2010	Taiwan	Case report	Class III anterior open bite (1)	SF (1)	LF (1p) + B + G	<ol style="list-style-type: none"> <li>1. Clockwise rotation of the palatal plane for upper incisor decompensation</li> <li>2. Lingual holding arch for lower incisor proclination (decompensation)</li> </ol>	<ol style="list-style-type: none"> <li>1. Class I molar</li> <li>2. Optimal interdigitation with minimal canine interference</li> <li>3. Stable posterior occlusion</li> </ol>
5	Liao et al., <sup>8</sup> 2010	Taiwan	Retrospective cohort study	Class III anterior open bite (33)	SF (20) OF (13)	LF (1 or 2p) + B + G	<ol style="list-style-type: none"> <li>1. Clockwise rotation of the palatal plane or upper premolar extraction for upper incisor decompensation</li> <li>2. Occlusal adjustment or intermaxillary elastics for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. Class I or II or III molar (as antero-posterior guide)</li> <li>2. No complete posterior skeletal crossbite</li> <li>3. Deep bite or posterior openbite</li> </ol>
6	Liou et al., <sup>10</sup> 2011	Taiwan	Case series	Class II (1) and Class III (2 facial asymmetry, 2 anterior open bite)	SF (5)	<ol style="list-style-type: none"> <li>1. LF (1 or 2p) + B + (G in 2 cases) for Class III</li> <li>2. B + G for Class II</li> </ol>	<ol style="list-style-type: none"> <li>1. Clockwise rotation of the palatal plane or upper premolar extraction for upper incisor decompensation</li> <li>2. Chin cap for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. Class I or II or III molar</li> <li>2. No complete posterior buccal crossbite</li> </ol>

No.	Author, year	Country	Study design	Deformity (No. of patients)	Approach (No. of patients)	Surgery	Orthodontic Mechanism	Guideline of Surgical Occlusion Setup
7	Villegas et al., <sup>14</sup> 2012	Columbia	Case report	Class III (1)	SF (1)	LF (1p) + B	<ol style="list-style-type: none"> <li>1. Clockwise rotation of the palatal plane or upper premolar extraction for upper incisor decompensation</li> <li>2. Intermaxillary elastics for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. Class I molar</li> </ol>
8	Park et al., <sup>15</sup> 2013	Korea	Case report	Class III facial asymmetry (1 anterior open bite, 1 overbite)	SF (2)	LF (1p) + I	<ol style="list-style-type: none"> <li>1. Intermaxillary elastics and occlusal splint for muscle adaptation to the new jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. Class I molar</li> </ol>
9	Aymach et al., <sup>16</sup> 2013	USA	Case report	Class III (1)	SF (1)	B	<ol style="list-style-type: none"> <li>1. SAS for distalization of maxillary dentition</li> <li>2. Occlusal splint for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. Class II molar</li> </ol>
10	Kim et al., <sup>17</sup> 2014	Korea	Retrospective cohort study	Class III (61)	SF (23) OF (38)	B	<ol style="list-style-type: none"> <li>1. Intermaxillary elastics and occlusal splint for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. At least 3 stable occlusal stops</li> <li>2. No transverse discrepancy</li> </ol>
11	Yu et al., <sup>18</sup> 2015	China	Retrospective case series	Bimaxillary protrusion (11); Class III (27); facial asymmetry (12)	SF (50)	<ol style="list-style-type: none"> <li>1. LF (2p) + A + (B in 2 cases) + (G in 2 cases) for bimaxillary protrusion</li> <li>2. (LF in 19 cases) + (B in 26 cases) + (G in 4 cases) for Class III</li> </ol>	NA	<ol style="list-style-type: none"> <li>1. Molar is the guide</li> <li>2. Appropriate buccal overjet</li> </ol>
12	Gandedkar et al., <sup>19</sup> 2015	Singapore	Case report	Class III (2)	SF (2)	(LF in 1 case) + B + (G in 1 case)	<ol style="list-style-type: none"> <li>1. Upper premolar extraction for upper incisor decompensation</li> <li>2. Chin cap for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. Positive overjet</li> <li>2. At least 3 stable occlusal stops</li> <li>3. Posterior crossbite not more than one buccal cusp width of maxillary molar</li> <li>4. Posterior openbite in hypodivergent cases</li> </ol>
13	Mah et al., <sup>20</sup> 2017	Korea	Retrospective cohort study	Class III (40)	SF (20) OF (20)	B	<ol style="list-style-type: none"> <li>1. Occlusal adjustment or occlusal stops for stabilization of jaw position</li> </ol>	<ol style="list-style-type: none"> <li>1. At least 3 occlusal stops</li> </ol>

A: ASO, mandibular anterior subapical osteotomy; B: BSSO, bilateral sagittal splitting osteotomy; C: mandibular contouring; G: genioplasty; I: IVRO, intraoral vertical ramus osteotomy; LF (1 or 2 p): Le Fort I osteotomy (1-piece or 2-piece); NA: not available; OF: orthodontics-first approach; SF: surgery-first approach; SAS: skeletal anchorage system

**Table 2.** Quality assessment of the included studies (N = 13)

No	Author, year	Random Sampling	Subject selection described	Valid method	Confounding factors considered	Adequate statistics provided	Study quality
1	Nagasaka et al <sup>5</sup> 2009	No	Yes	No	Not declared	No	Low
2	Villegas et al <sup>6</sup> 2010	No	Yes	No	Not declared	No	Low
3	Baek et al <sup>13</sup> 2010	No	Yes	No	Not declared	No	Low
4	Yu et al <sup>7</sup> 2010	No	Yes	No	Not declared	No	Low
5	Liao et al <sup>8</sup> 2010	No	Yes	No	Yes	No	Low
6	Liou et al <sup>10</sup> 2011	No	Yes	No	Not declared	No	Low
7	Villegas et al <sup>14</sup> 2012	No	Yes	No	Not declared	No	Low
8	Park et al <sup>15</sup> 2013	No	Yes	No	Not declared	No	Low
9	Aymach et al <sup>16</sup> 2013	No	Yes	No	Not declared	No	Low
10	Kim et al <sup>17</sup> 2014	No	Yes	No	Yes	No	Low
11	Yu et al <sup>18</sup> 2015	No	Yes	No	Not declared	No	Low
12	Gandedkar et al <sup>19</sup> 2015	No	Yes	No	Not declared	No	Low
13	Mah et al <sup>20</sup> 2017	No	Yes	No	Yes	No	Low

## DISCUSSION

Despite the evident advantages of surgery-first orthognathic surgery, it lacks worldwide popularity. One of the challenges for the surgery-first approach is the surgical occlusion setup. For example, in classic (i.e., orthodontics-first) approach pre-surgical orthodontic treatment brings maxillary and mandibular teeth into ideal relationships to their individual underlying skeletal bases,<sup>21,22</sup> so the surgical occlusion is very close to the final occlusion (i.e., ideal occlusion) after complete pre-surgical orthodontic treatment. Thus, in orthodontics-first approach, surgical occlusion ideally is set as normal overjet and overbite,<sup>21,23,24</sup> Class I canine and molar relationship,<sup>21-26</sup> tooth-to-tooth contacts,<sup>22,26,27</sup> and no occlusal interference.<sup>22,24,27</sup> In contrast, in surgery-first approach, dental decompensation is deferred after surgery, so the surgical occlusion is different from the

final occlusion. The surgical occlusion setup serves to foresee the tooth movements necessary to achieve an ideal occlusion after post-surgical orthodontic treatment. Thus, the occlusion is set as treatable malocclusion. Accurate surgical occlusion setup is important so surgery-first approach is not suggested to be managed by an orthodontist with limited experience in orthognathic surgery.<sup>8,9,18</sup>

This systematic review provided inconclusive evidence about the guidelines of surgical occlusion setup for Class III malocclusion using the surgery-first approach. The reasons for the discordant results are due to the heterogeneity of the samples in the selected studies, as shown by the variety of the deformity types, surgical design, and orthodontic mechanisms or techniques used in post-surgical orthodontics (Table 1), as well as the methodological deficiencies (Table 2). These are described in more details as below.

In the sagittal dimension, seven studies used first molars as a guide for antero-posterior dental position<sup>7,8,10,14-16,18</sup> as incisors cannot be used as a guide in the sagittal dimension (i.e., incomplete horizontal skeletal correction) in contrast to classic surgical-orthodontic treatment, in which incisor decompensation is performed before surgery. Therefore, when nonextraction was performed in the lower arch the molar relationship could be either Class I when clockwise rotation of the palatal plane was used for upper incisor decompensation<sup>7,10,14,19</sup> or Class II when upper premolar extraction<sup>10,19</sup> or distalization of the maxillary dentition with Skeletal Anchorage System (SAS)<sup>5,6,16</sup> was used for upper incisor decompensation.

Because arch coordination is deferred after surgery with the surgery-first approach, the occlusion setup in the transverse dimension often poses a significant challenge. Four studies used little or no posterior crossbite as a guide for transverse dental position<sup>10,13,18,19</sup> because their philosophy was to achieve stable posterior occlusion and limit the post-surgical orthodontics to antero-posterior dental movement only. In other words, surgical occlusion setup should at most require only antero-posterior dental adjustment with minimal transverse or vertical dental movement.<sup>28</sup> Therefore, severe arch incoordination, either skeletal or dental origin, are corrected by maxillary segmental surgery. On the other hand, maxillary segmental surgery is only indicated for severe skeletal crossbite (i.e., skeletal origin) in one study.<sup>8</sup> In contrast to previous philosophy, posterior dental crossbite, either complete or incomplete, or mild skeletal crossbite are corrected by bending of orthodontic archwire, inter- or intra-arch elastics, transpalatal arch or lingual arch after surgery (i.e., the orthodontic way).

In the vertical dimension, only two studies<sup>8,19</sup> mentioned deep overbite or posterior open bite as a guide

for supero-inferior dental position in order to compensate for the space for dental alignment, and arch leveling and coordination after surgery. The posterior open bite is easier to correct than anterior open bite after surgery; therefore, surgical occlusion setup with anterior open bite should be avoided. The posterior open bite is also helpful for correction of posterior cross bite from buccoversion of maxillary molars (i.e., dental origin), which is quite common in Class III malocclusion, due to unlocked occlusion. On the other hand, one study suggested anterior open bite in order to achieve stable posterior occlusion.<sup>5</sup>

The need for stable surgical occlusion was emphasized in eight studies.<sup>5-7,13,14,17,19,20</sup> However, definition of stable occlusion varied between studies; four studies defined stable occlusion as at least 3-point contact,<sup>13,17,19,20</sup> whereas another four defined it as stable posterior occlusion.<sup>5-7,14</sup> To prevent unstable jaw position from occlusal instability after surgery, six studies used an occlusal splint,<sup>5,13,15-17,20</sup> another 2 studies used a chin cap,<sup>10,19</sup> and the other four studies used intermaxillary elastics.<sup>8,14,15,17</sup>

## CONCLUSIONS

The studies in our systematic review yielded contradictory results and lacked high quality, therefore the scientific evidence was too weak to identify the guidelines for surgical occlusion setup in surgery-first orthognathic surgery for Class III malocclusion. Further high-quality studies are required. Accurate dental occlusion setup should be pursued to avoid severe postoperative occlusal instability, incomplete or excessive skeletal correction, or skeletal asymmetry. Employing a 3-dimensional virtual simulation process to assess the accuracy of occlusion setup in terms of skeletal deformity could establish new clinical guidelines for occlusion setup in the sagittal, vertical, and transverse dimensions.

## ACKNOWLEDGEMENTS

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