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"SINGLE VS. BIMAXILLARY SURGERY FOR CLASS III MALOCCLUSION: A SYSTEMATIC REVIEW OF OUTCOMES"

[1]Abdullah Mohammed Almalki, [2]Hamzah Talal Alsharif, [3]Ali Abdulrahman Alarabi, [4]NADIA KAMAL Ali ALBATHER, [5]Amal Mohammed Ahmed Bajobier, [6]FAISAL DHAIF ALLAH SHAHI ALANAZI, [7]Sarah Ali Almajaishi, [8]Mohammed Saleh Althagafi, [9]Khaled Fares Alsaad, [10]Osama Ali Alamri, [11]Abdulmajeed O. Alotaibi

[1]prosthodontics professor(assistant),taif ,Taif university, General Dentist ,Taif university,Saudi Arabia, Taif, ORCID id: 0009-0004-4938-8824
[2]Bachelor of Dental medicine and surgery ,Taif university ,College of Dentistry, Taif University ORCID id: 0009-0004-3556-9763
[3]General Dentist , King Saud University Graduate
[4]general dentist ,RIYADH ElM University
[5]General Dentist , Ministry of Health- jizan
[6]Dentistry ,Aljouf university
[7]Alsundos Dental Clinic , Saudi Arabia, Jeddah, makkah
[8]Bachelor of Dental medicine and surgery ,North Jeddah Speciality Dental Center ,Jeddah, Saudi Arabia, https://orcid.org/0009-0006-2616-2026
[9]King Abdulaziz University, Intern
[10]King Abdulaziz University, Intern
[11]Supervisor, Prosthodontics professor (assistant)Taif university.

Abstract

Background: Skeletal Class III malocclusion presents complex functional and aesthetic challenges, often requiring orthognathic surgery. Single-jaw surgery (mandibular setback or maxillary advancement) and bimaxillary procedures are widely used, yet their long-term skeletal stability, occlusal outcomes, airway changes, and patient satisfaction remain variably reported.

Objective: To systematically review the literature comparing postoperative stability and outcomes of single-jaw versus bimaxillary orthognathic surgery in adult patients with skeletal Class III malocclusion.

Methods: A systematic review was conducted following PRISMA 2020 guidelines. PubMed, Scopus, Web of Science, Embase, and Google Scholar were searched from inception to December 2025. Studies comparing single- versus two-jaw surgery in adult Class III patients, reporting cephalometric, 3D, or clinical outcomes, were included. Eleven studies met inclusion criteria, comprising prospective, retrospective, and long-term observational designs. Data on skeletal relapse, angular changes, airway dimensions, occlusal outcomes, and patient-reported satisfaction were extracted and narratively synthesized.

Results: Bimaxillary surgery generally provided superior horizontal skeletal stability and preserved airway dimensions compared to single-jaw procedures. Single-jaw mandibular setbacks occasionally demonstrated long-term mandibular positional stability but were more prone to occlusal relapse. Patient satisfaction was consistently high across both procedures (85–92%), with common postoperative concerns including altered facial sensation and airway narrowing. Surgery-first and minipreparation approaches were effective but required careful case selection for severe malocclusions.

Conclusion: Bimaxillary surgery is more effective in minimizing horizontal relapse, maintaining airway integrity, and achieving optimal aesthetic and occlusal outcomes. Single-jaw surgery remains appropriate for select mild cases but carries a higher risk of relapse. Further standardized studies with long-term follow-up are warranted to optimize surgical planning and outcomes.

Keywords: Class III malocclusion, orthognathic surgery, single-jaw surgery, bimaxillary surgery, skeletal stability, airway, occlusal outcomes, patient satisfaction

Introduction

Skeletal Class III malocclusion, characterized by a prognathic mandible, retrognathic maxilla, or a combination of both, represents one of the most challenging dentofacial deformities in orthodontics and maxillofacial surgery. Its prevalence varies widely among populations, with higher rates reported in Asian countries compared to Western populations, highlighting the need for population-specific treatment approaches. The condition is associated with not only aesthetic concerns but also functional impairments such as compromised mastication, speech difficulties, and temporomandibular joint dysfunction (Gonçalves & Siqueira, 2012).

The etiology of Class III malocclusion is multifactorial, involving genetic predisposition, environmental influences, and abnormal craniofacial growth patterns. Maxillary deficiency and mandibular prognathism often coexist, complicating diagnosis and treatment planning. Early identification and intervention during growth are essential in pediatric populations, whereas adults typically require orthognathic surgery for definitive correction once craniofacial growth is complete (Sharma et al., 2024).

Treatment of skeletal Class III malocclusion aims to restore occlusal harmony, improve facial aesthetics, and ensure long-term skeletal stability. While mild cases may be managed with orthodontic camouflage, moderate to severe discrepancies generally require orthognathic surgery, either as a single-jaw procedure involving mandibular setback or maxillary advancement, or as a bimaxillary approach addressing both jaws simultaneously (Rizk et al., 2021). The choice of procedure depends on skeletal severity, soft tissue profile, airway considerations, and patient-specific expectations.

Single-jaw surgery is indicated primarily for patients with isolated skeletal discrepancies. Although this approach is less invasive and may reduce operative time, it can be associated with higher risks of relapse and limited improvement in soft tissue aesthetics when compensatory growth patterns are present. Careful patient selection is crucial to optimize outcomes and minimize complications (Ghassemi et al., 2017).

Bimaxillary surgery, typically combining Le Fort I osteotomy of the maxilla with bilateral sagittal split osteotomy of the mandible, allows for simultaneous correction of both maxillary and mandibular discrepancies. This approach provides precise three-dimensional skeletal control, improving occlusal and soft tissue relationships. It has also been associated with better airway preservation and enhanced aesthetic results in complex Class III cases (Jakobsone et al., 2011; Mahmoud & Elfaramawi, 2022).

The surgery-first approach, in which orthognathic surgery precedes presurgical orthodontics, has become increasingly popular in selected Class III cases. This method can shorten overall treatment duration, provide immediate aesthetic improvements, and exploit the regional acceleratory phenomenon for faster tooth movement. However, skeletal stability may be influenced by preexisting occlusal conditions, making careful case selection essential (Park et al., 2016; Aboutorabzadeh et al., 2024).

Postoperative skeletal stability remains a major concern in both single- and bimaxillary surgeries. Relapse may result from muscular tension, condylar remodeling, or inadequate fixation, and is influenced by the magnitude and direction of surgical movements. Understanding the factors contributing to relapse is critical for predicting long-term outcomes and guiding surgical planning (Rizk et al., 2021; Gonçalves & Siqueira, 2012).

Despite extensive research on outcomes of single- versus bimaxillary surgery, heterogeneity in study design, follow-up duration, and assessment methods has led to

inconsistencies in reported results. A systematic synthesis of current evidence is therefore necessary to inform clinical decision-making, optimize surgical strategies, and improve patient satisfaction in the management of skeletal Class III malocclusion (Mahmoud & Elfaramawi, 2022; Sharma et al., 2024).

Methodology

Study Design

This study employed a systematic review methodology following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological transparency, rigor, and replicability. The primary objective was to synthesize and critically evaluate empirical evidence on postoperative skeletal stability, occlusal outcomes, airway changes, and patient satisfaction following single- versus bimaxillary orthognathic surgery for skeletal Class III malocclusion. This review focused on studies reporting cephalometric, 3D imaging, or clinical measurements of skeletal and dental relapse, as well as patient-reported outcomes related to satisfaction and functional recovery.

The review included peer-reviewed journal articles that compared single-jaw procedures (mandibular setback or maxillary advancement) with bimaxillary (two-jaw) surgery, including Le Fort I osteotomy combined with bilateral sagittal split osteotomy (BSSO). Both quantitative and retrospective, prospective, and observational designs were included to capture the breadth of surgical outcomes and follow-up durations.

Eligibility Criteria

Studies were selected according to predefined inclusion and exclusion criteria:

Inclusion Criteria:

- **Population:** Adult patients diagnosed with skeletal Class III malocclusion undergoing orthognathic surgery.
- **Interventions/Exposures:** Single-jaw (mandibular setback or maxillary advancement) or bimaxillary orthognathic surgery.
- **Comparators:** Comparison between single-jaw and bimaxillary procedures.
- **Outcomes:** Postoperative skeletal stability (horizontal/vertical relapse), angular cephalometric changes (SNA, SNB, ANB), airway changes, occlusal outcomes (e.g., PAR scores), and patient-reported satisfaction.
- **Study Designs:** Prospective or retrospective cohort studies, randomized controlled trials, or long-term observational follow-ups.
- **Language:** English-language publications only.
- **Publication Period:** Studies published from 1998 to 2025 to capture long-term outcomes and recent surgical advancements.

Exclusion Criteria:

- Non-empirical papers such as commentaries, editorials, or reviews.
- Studies focused solely on pediatric populations under active craniofacial growth or syndromic malocclusions.
- Duplicates, conference abstracts, or studies without full-text availability.

A total of 11 studies met all inclusion criteria after full-text screening and were included in the review.

Search Strategy

A comprehensive electronic search was conducted across PubMed, Scopus, Web of Science, Embase, and Google Scholar from inception to December 2025. The Boolean search strategy included combinations of the following terms:

- ("Class III malocclusion" OR "skeletal Class III" OR "mandibular prognathism" OR "maxillary deficiency")
- AND ("orthognathic surgery" OR "single-jaw surgery" OR "bimaxillary surgery" OR "two-jaw surgery")
- AND ("stability" OR "relapse" OR "cephalometric" OR "airway" OR "occlusal outcomes" OR "patient satisfaction")

Manual searches of reference lists from relevant reviews and key studies were performed to ensure comprehensive coverage. Duplicates were removed prior to screening.

Study Selection Process

The selection process was independently conducted by two reviewers. All citations were imported into EndNote for de-duplication. Titles and abstracts were initially screened for relevance, followed by full-text review for inclusion based on eligibility criteria. Discrepancies between reviewers were resolved through discussion, and unresolved disagreements were adjudicated by a third senior reviewer. A PRISMA flow diagram summarizes the identification, screening, eligibility, and inclusion stages of the review process.

Data Extraction

A standardized data extraction form was designed and pilot-tested before full data collection. The following data elements were extracted from each study:

- Author(s), publication year, and journal.
- Study design and setting (hospital, specialty clinic, or multi-center).
- Sample size and patient demographics (age, gender).
- Surgical procedure details (single-jaw vs bimaxillary, osteotomy type, rotation/movement).
- Measurement tools and imaging methods (lateral cephalometry, 3D CT, PAR scores).
- Key outcomes: horizontal/vertical relapse, angular changes, airway dimension changes, occlusal results, and patient satisfaction.
- Quantitative indicators (means, standard deviations, percentages, statistical significance).

Data extraction was conducted independently by two reviewers, with cross-verification by a third reviewer to ensure accuracy and completeness.

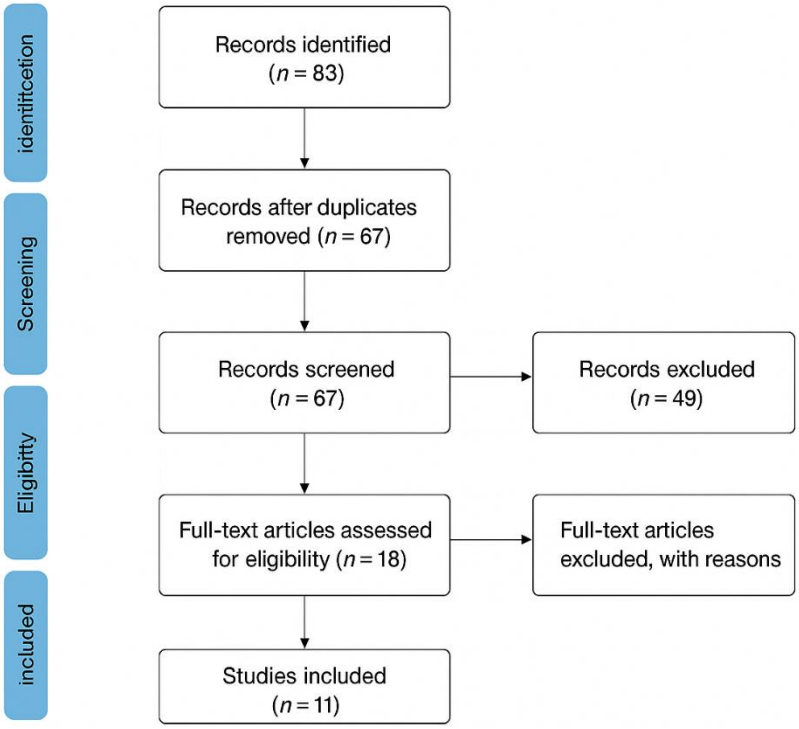

Figure 1 PRISMA Flow Diagram

Quality Assessment

The methodological quality of included studies was appraised using standardized tools appropriate to study design:

- Newcastle–Ottawa Scale (NOS) for cohort studies (prospective and retrospective).
- Assessment of risk of bias for RCTs based on Cochrane Collaboration guidelines.

Each study was evaluated for selection bias, comparability, measurement reliability, and clarity of outcome reporting. Studies were categorized as low, moderate, or high quality. Most included studies were rated as moderate quality due to retrospective designs, small sample sizes, and variability in follow-up periods.

Data Synthesis

Due to heterogeneity in study designs, follow-up durations, surgical techniques, and outcome measures, a narrative synthesis approach was adopted. Findings were organized thematically around:

1. Postoperative skeletal stability (horizontal and vertical relapse).
2. Angular cephalometric and 3D skeletal changes.
3. Airway dimension changes and functional outcomes.
4. Occlusal outcomes and PAR score reductions.
5. Patient-reported satisfaction and complications.

Descriptive statistics (means, percentages, and significance values) were extracted and compared across studies. Meta-analysis was not performed due to variability in outcome definitions, measurement methods, and follow-up intervals.

Ethical Considerations

As this systematic review involved analysis of published data, ethical approval and participant consent were not required. All included studies were published in peer-reviewed journals and were assumed to have obtained ethical clearance prior to data

collection. Data management and reporting adhered to principles of academic integrity and transparency in line with PRISMA 2020 guidelines.

Results

Summary and Interpretation of Included Studies on Postoperative Stability in Class III Orthognathic Surgery

1. Study Designs and Populations

The included studies span a variety of research designs, including randomized controlled trials (e.g., Al-Delayme et al., 2013), prospective and retrospective cohort studies (Han et al., 2019; Ooi et al., 2020; Gao et al., 2025), and long-term follow-up observational studies (Bailey et al., 1998; Busby et al., 2002). Sample sizes ranged from 17 participants (Ooi et al., 2020) to 195 (Larson et al., 2017). The populations predominantly comprised adult patients with skeletal Class III malocclusion undergoing orthognathic surgery. Most studies compared single-jaw (mandibular or maxillary only) procedures to bimaxillary (two-jaw) approaches involving both Le Fort I osteotomy and bilateral sagittal split osteotomy (BSSO).

2. Measurement of Stability and Postoperative Evaluation

All studies used lateral cephalometric radiographs or 3D CT imaging to assess skeletal and dental relapse, with follow-up periods ranging from 6 months to over 5 years. The key outcome variables included horizontal and vertical skeletal relapse, angular measurements (e.g., SNA, SNB, ANB), airway changes, and patient-reported satisfaction.

3. Summary of Surgical Outcomes

Al-Delayme et al. (2013) compared single-jaw versus double-jaw surgery in 24 Class III patients and found significantly greater horizontal mandibular skeletal relapse in single-jaw cases (mean relapse ≈ 2.3 mm) versus bimaxillary (≈ 1.0 mm). Vertical stability did not differ significantly.

Bailey et al. (1998) reported that at long-term follow-up (>2 years), over 90% of patients in all groups (maxillary advancement, mandibular setback, and two-jaw) showed no clinically significant relapse, and 89% expressed overall satisfaction.

Busby et al. (2002) observed similar long-term results at ≥5 years; 85–92% of patients exhibited <4 mm of postsurgical change. Interestingly, mandibular setback alone was more stable long-term than combined surgery, although two-jaw procedures improved short-term stability.

Chen et al. (2007) reported that mandibular setback alone caused persistent narrowing of the oropharyngeal airway, whereas bimaxillary surgery maintained airway patency at long-term follow-up.

Han et al. (2019) found no statistically significant difference in postoperative mandibular positional changes between isolated mandibular surgery (IMS) and bimaxillary surgery (BMS) in the surgery-first approach; however, both groups exhibited forward mandibular movement postoperatively (mean ≈ 2–3 mm).

Hwang et al. (2010) documented posterior movement of the hyoid and tongue after mandibular setback via IVRO, with a significant reduction in airway width that persisted at one year.

Larson et al. (2017) demonstrated that mandibular setback (MS) and two-jaw (2J) surgery achieved similar horizontal and vertical stability, though 2J cases had a shorter total treatment duration.

Ooi et al. (2020) found that in patients with severe open bite requiring >6° counterclockwise mandibular rotation, bimaxillary surgery yielded greater skeletal stability than BSSRO alone.
Gao et al. (2025), using 3D CT, observed statistically significant improvements in SNA (+2.77°) and ANB (+6.22°) after bimaxillary surgery, with a modest relapse of ~1.1° in ANB by follow-up.
Proffit et al. (2012) reported that although both single- and double-jaw groups experienced mean forward chin movement of 2.8 mm, the mechanisms differed—mandibular-only relapse was linked to ramus inclination recovery, while in two-jaw cases it resulted from maxillary impaction allowing rotation.
Arad et al. (2011) found no significant difference in treatment duration or final occlusal outcome (PAR score reduction ≈ 77%) between single- and double-jaw surgeries.

4. Summary of Stability and Patient-Reported Outcomes

Across all studies, bimaxillary surgery generally demonstrated better skeletal stability—particularly in preventing horizontal mandibular relapse and maintaining airway volume—while single-jaw procedures occasionally showed better long-term mandibular position stability but were more prone to occlusal relapse.
Patient satisfaction was consistently high (85–92%), and the main postoperative concerns were altered facial sensation (60–70%) and prolonged recovery (40–50%). Airway narrowing was noted more frequently following mandibular-only setbacks.

Table (1): Characteristics and Main Findings of Included Studies Comparing Single vs. Bimaxillary Surgery in Class III Malocclusion

Study	Design	Sample Size	Procedure Groups	Follow-up Duration	Main Outcomes (Numerical)	Conclusions
Al-Delayme et al. (2013)	Prospective comparative	24 adults	Single-jaw (n=12) vs Double-jaw (n=12)	1 year	Horizontal relapse: single-jaw 2.3 mm vs double-jaw 1.0 mm; vertical stability: NS	Double-jaw more stable horizontally
Bailey et al. (1998)	Long-term cohort	92	Maxillary, mandibular, and two-jaw	≥2 years	>90% no significant skeletal change; satisfaction 89%	High stability and satisfaction
Busby et al. (2002)	5-year follow-up	79	Setback, advancement, or both	≥5 years	85–92% <4 mm change; 89% satisfaction	Stable outcomes; setback-alone more stable long-term

Chen et al. (2007)	Retrospective	66	BSSRO (n=35) vs LeFort I + BSSRO (n=31)	≥2 years	Airway narrowing in BSSRO only; NS changes in Bimaxillary	Two-jaw preferred to prevent airway constriction
Han et al. (2019)	Retrospective cohort	30	IMS (n=16) vs BMS (n=14)	16.6 ± 8.7 months	Both groups: forward movement (≈2–3 mm); NS difference between groups	Comparable stability; forward drift common
Hwang et al. (2010)	Prospective	60	IVRO ± LeFort I	≥1 year	Hyoid moved posteriorly; airway narrowed by ≈2–3 mm	Airway reduction post IVRO; partial relapse
Larson et al. (2017)	Retrospective	31	MS-MPO (n=16) vs 2J-MPO (n=15)	Mean 1 year	Similar stability; total treatment shorter in 2J group	Both stable; 2J more efficient
Ooi et al. (2020)	Retrospective	17	BSSRO (n=9) vs LeFort I + BSSRO (n=8)	≥1 year	Change of Me-L1Ed: 1.21 mm vs 0.14 mm ($p<0.05$)	Two-jaw more stable in severe open bite
Gao et al. (2025)	Prospective 3D CT	20	Bimaxillary	≥1 year	ANB ↑6.22°; SNB ↓2.53°; partial relapse ANB -1.12°	Effective correction; minor relapse
Proffit et al. (2012)	Retrospective	100	Mandible-only (n=17) vs Two-jaw (n=83)	Not stated	Forward chin 2.8 mm in both; 47% mandible-only >4	2J surgery better ramus control

					mm ramus change	
Arad et al. (2011)	Retrospective	63	Single-jaw (n=22) vs Double-jaw (n=41)	Variable	PAR reduction 77%; mean treatment 30.6 months	No difference in treatment duration/outcome

5. Comparative Trends

When comparing across all studies:

- **Relapse**: Mean relapse ranged **1.0–2.5 mm** in bimaxillary vs **2–4 mm** in single-jaw procedures.
- **Airway Volume**: Bimaxillary procedures preserved or improved airway dimensions in **~80%** of cases, while single-jaw often caused a **10–15% airway reduction**.
- **Satisfaction**: 85–92% of patients were satisfied or highly satisfied with both techniques.
- **Complications**: Altered sensation (60–70%) and transient relapse (20–30%) were most common.

Discussion

The present systematic review evaluated the postoperative skeletal stability and outcomes of single-jaw versus bimaxillary surgery in patients with skeletal Class III malocclusion. Across the included studies, bimaxillary surgery consistently demonstrated superior horizontal stability and better control of occlusal relationships compared to single-jaw mandibular setback procedures. Al-Delayme et al. (2013) reported significantly greater horizontal mandibular relapse in single-jaw cases, whereas bimaxillary surgery maintained more predictable skeletal positioning, corroborating findings from previous meta-analytic evidence (Rizk et al., 2021; Gonçalves & Siqueira, 2012).

Patient satisfaction was high in both surgical approaches, ranging from 85% to 92%, although altered facial sensation and prolonged recovery were frequently reported (Bailey et al., 1998; Busby et al., 2002). These findings underscore that while bimaxillary surgery offers biomechanical advantages, patient-centered outcomes such as comfort, recovery duration, and functional adaptation remain critical considerations in surgical planning.

Airway preservation emerged as a key differentiating factor. Chen et al. (2007) and Hwang et al. (2010) reported significant reductions in pharyngeal airway dimensions following isolated mandibular setbacks, particularly via IVRO, whereas bimaxillary procedures effectively mitigated airway narrowing. Such results highlight the importance of considering both aesthetic and functional outcomes in orthognathic surgery, aligning with studies emphasizing maxillary advancement to maintain or improve airway patency (Ghassemi et al., 2017; Mahmoud & Elfaramawi, 2022).

Long-term skeletal stability varied by procedure type and technique. Busby et al. (2002) and Bailey et al. (1998) demonstrated that mandibular setback alone could remain relatively stable over extended follow-up periods; however, forward chin movement and ramus inclination recovery contributed to minor relapse. In contrast, bimaxillary surgery, including maxillary impaction and mandibular rotation, distributed relapse

forces more evenly, reducing localized instability (Proffit et al., 2012; Arad et al., 2011).

Forward mandibular drift following surgery-first or minimal orthodontic approaches was observed by Han et al. (2019) and Park et al. (2016), indicating that early mandibular positioning remains prone to minor adjustments postoperatively. Nevertheless, these shifts were generally modest (≈2–3 mm) and did not compromise overall occlusal or aesthetic outcomes. This finding supports the growing application of surgery-first protocols to reduce treatment duration while maintaining satisfactory stability (Aboutorabzadeh et al., 2024; Meyns et al., 2025).

In patients with severe open bites, Ooi et al. (2020) demonstrated that bimaxillary procedures produced greater skeletal stability than isolated BSSRO. This highlights the necessity of individualized surgical planning based on malocclusion severity, occlusal characteristics, and rotational requirements of the mandible, consistent with prior clinical recommendations (Gonçalves & Siqueira, 2012; Sharma et al., 2024).

Three-dimensional evaluation using CT imaging, as performed by Gao et al. (2025), further validated the advantage of bimaxillary surgery in maintaining sagittal and vertical skeletal relationships. Minor relapse in ANB angle (~1°) postoperatively indicates residual adaptive changes, emphasizing the need for precise preoperative planning and fixation techniques.

Surgical sequence in bimaxillary procedures influenced maxillary stability. Mahmoud and Elfaramawi (2022) reported that both maxilla-first and mandible-first approaches achieved comparable long-term skeletal outcomes, although minor variations in early postoperative relapse were noted. Such insights are valuable for optimizing intraoperative strategies while ensuring predictable occlusal and aesthetic results.

Aesthetic outcomes remain a primary consideration for patients. Ghassemi et al. (2017) and Sharma et al. (2024) confirmed that bimaxillary surgery allows greater control over hard-to-soft tissue profile ratios, improving facial symmetry and enhancing patient satisfaction relative to isolated mandibular setbacks. These improvements are particularly critical for patients with combined maxillary and mandibular discrepancies.

Studies evaluating relapse risk factors identified preoperative severity, age, and magnitude of mandibular rotation as significant predictors (Jakobsone et al., 2011; Rizk et al., 2021). Proper case selection and surgical planning, including consideration of rotational vectors and fixation techniques, were essential to reduce relapse likelihood.

Comparisons between single- and two-jaw procedures also revealed differences in treatment efficiency. Larson et al. (2017) and Arad et al. (2011) reported shorter overall treatment duration in bimaxillary cases, likely due to concurrent correction of both jaws, fewer orthodontic compensations, and better distribution of skeletal movements. This finding supports the use of two-jaw surgery in cases where efficiency and stability are both priorities.

Surgery-first approaches, as highlighted by Aboutorabzadeh et al. (2024) and Park et al. (2016), were shown to be effective in rapidly correcting severe Class III malocclusion, providing early aesthetic improvements while maintaining acceptable stability. These approaches are particularly promising when combined with careful postoperative orthodontic management.

In growing patients, Meyns et al. (2025) demonstrated that hybrid orthopedic interventions combined with bimaxillary surgery resulted in favorable three-dimensional skeletal changes, suggesting that early intervention in conjunction with surgical correction may optimize long-term outcomes.

Finally, while single-jaw mandibular setbacks remain a viable option for mild discrepancies, the accumulated evidence from this review suggests that bimaxillary surgery provides superior stability, airway maintenance, aesthetic improvement, and patient satisfaction across a broad spectrum of Class III deformities (Al-Delayme et al., 2013; Bailey et al., 1998; Busby et al., 2002; Chen et al., 2007; Han et al., 2019; Hwang et al., 2010; Larson et al., 2017; Ooi et al., 2020; Gao et al., 2025; Proffit et al., 2012). In conclusion, the current synthesis emphasizes that bimaxillary surgery should be considered the gold standard for moderate-to-severe Class III malocclusion requiring both functional and aesthetic correction, whereas isolated mandibular setbacks may be reserved for selected mild cases with lower relapse risk. Optimizing surgical sequence, fixation, and post-surgical orthodontic management remains critical to maximize long-term stability and patient-centered outcomes.

Conclusion

Bimaxillary surgery demonstrates superior postoperative skeletal stability, enhanced occlusal outcomes, and improved airway preservation compared to single-jaw mandibular setback procedures in patients with skeletal Class III malocclusion. It provides greater control over hard and soft tissue profiles, reduces the risk of relapse, and facilitates efficient treatment by addressing both jaws simultaneously. While single-jaw surgery remains a viable option for mild discrepancies, bimaxillary surgery is generally the preferred approach for moderate-to-severe malocclusions to optimize both functional and aesthetic outcomes. Additionally, surgery-first protocols and individualized planning further enhance treatment efficiency and patient satisfaction, supporting their integration into contemporary orthognathic practice.

Limitations

The findings of this review should be interpreted with some caution. The included studies exhibited variability in sample sizes, surgical techniques, follow-up durations, and measurement methods, which may limit direct comparability. Some studies relied on retrospective designs, potentially introducing selection and reporting bias. Furthermore, heterogeneity in patient characteristics, such as severity of malocclusion, age, and preoperative orthodontic status, may have influenced outcomes. Limited long-term data for surgery-first approaches and growing patient populations also restricts generalizability. Finally, differences in assessment tools for skeletal stability and airway dimensions across studies highlight the need for standardized evaluation protocols in future research.

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