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(REVIEW ARTICLE)

Long-Term Outcomes and Relapse Risk in Adult Protrusive Malocclusion: A Comparative Literature Review of Orthodontic and Orthognathic Treatment Modalities

Amalia Khusna Lathifah [1], Chyeisha Priscilla Serafinne [1] and Irma Josefina Savitri [2,*]

[1] *Faculty of Dental Medicine, Universitas Airlangga, St. Mayjend. Prof. Dr. Moestopo No. 47, Surabaya, 60132, Indonesia.*
[2] *Department of Periodontology, Faculty of Dental Medicine, Universitas Airlangga, St. Mayjend. Prof. Dr. Moestopo No. 47, Surabaya, 60132, Indonesia.*

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Abstract

Introduction: Adult protrusive malocclusion presents significant challenges due to the absence of craniofacial growth and limited adaptability of periodontal and neuromuscular structures. Achieving long-term stability requires precise diagnosis, controlled biomechanics, and retention planning. Orthodontic camouflage may suit mild-to-moderate discrepancies, whereas combined orthodontic–orthognathic treatment is preferred for severe skeletal imbalances. Relapse remains a concern across modalities, influenced by periodontal fiber memory, condylar remodeling, dentoalveolar compensation, and retention strategies.

Materials and Methods: A structured literature review following PRISMA guidelines included studies published between 2015 and 2025. Databases searched were PubMed, ScienceDirect, and Google Scholar. Inclusion criteria: adult patients with skeletal protrusive malocclusion treated via camouflage mechanics or orthognathic surgery, reporting outcomes ≥1 year. Five studies met all criteria. Data on treatment modality, skeletal pattern, follow-up, stability, relapse, and condylar changes were extracted. Narrative synthesis was performed due to methodological heterogeneity.

Results and Discussion: Orthognathic surgery consistently demonstrated superior skeletal and dental stability with minimal relapse up to 10 years and favorable condylar adaptation. Orthodontic camouflage showed greater variability with relapse primarily due to torque loss, dentoalveolar compensation, and unresolved skeletal discrepancies. High-angle cases benefited from miniscrew-assisted intrusion and counterclockwise rotation, but findings were limited. Retention protocols critically influenced outcomes, particularly for non-surgical cases.

Conclusion: Orthognathic surgery provides predictable long-term outcomes for adults with significant protrusive skeletal discrepancies. Camouflage is appropriate only for mild cases and carries higher relapse risk, especially in torque and condylar stability. Careful biomechanical planning, skeletal assessment, and long-term retention are essential to maintain post-treatment stability.

Keywords: Adult Orthodontics; Protrusive Malocclusion; Orthodontic Camouflage; Orthognathic Surgery; Long-Term Stability; Relapse

* Corresponding author: Irma Josefina Savitri

1. Introduction

Protrusive malocclusion in adults poses a significant clinical challenge due to the absence of craniofacial growth, reduced bone plasticity, and limited adaptability of the periodontal and neuromuscular systems [1]. Unlike adolescents, adult patients rely predominantly on dentoalveolar compensation rather than skeletal modification, which necessitates precise biomechanical control, individualized diagnosis, and careful evaluation of soft-tissue response to ensure both esthetic and functional stability [2, 3]. The complexity of protrusive malocclusion (whether maxillary, mandibular, or bimaxillary) demands carefully selected treatment modalities as inadequate planning or excessive dental compensation increases the risk of instability and long-term relapse [4].

Over the past decade, advancements in orthodontic mechanics, temporary anchorage devices (TADs), and orthognathic surgery techniques have expanded treatment options for adult patients. Orthodontic camouflage offers a less invasive approach and may be appropriate for mild to moderate protrusion by utilizing controlled retraction, torque management, and anchorage reinforcement. However, camouflage therapy has documented limitations, particularly in severe skeletal disharmony, where excessive dental retraction can compromise periodontal health and soft-tissue balance, ultimately reducing post-treatment stability [5]. In contrast, combined orthodontic–orthognathic treatment enables skeletal repositioning to correct underlying discrepancies showing superior improvements in airway dimensions, occlusal function, and long-term skeletal stability [6. 7]. Nevertheless, orthognathic surgery carries its own risks, such as condylar remodeling, relapse due to muscular rebound, and surgical complications, highlighting the importance of understanding the comparative long-term outcomes of each modality.

Relapse remains a central concern in the management of adult protrusive malocclusion. Factors contributing to relapse include periodontal fiber memory, inadequate remodeling of surrounding tissues, tongue posture, occlusal interferences, and insufficient retention [8]. Studies have shown that even surgically corrected cases may exhibit minor skeletal drift over time, whereas orthodontic camouflage outcomes tend to relapse dentoalveolarly if torque control and retention are suboptimal [6, 7]. Despite the wealth of literature, there remains a lack of consolidated evidence comparing long-term stability between camouflage orthodontics and orthognathic surgery specifically for protrusive adult cases.

Given the clinical, functional, and esthetic implications of protrusive malocclusion in adults, a comprehensive understanding of long-term treatment outcomes is critical for guiding therapeutic decisions. This review synthesizes evidence from recent studies evaluating long-term stability, relapse tendencies, and skeletal versus dentoalveolar outcomes in adult patients treated with orthodontic camouflage or combined orthodontic–orthognathic modalities. By integrating findings from multiple long-term follow-up studies, this review aims to clarify the relative efficacy, limitations, and relapse risks of each approach, ultimately supporting clinicians in delivering evidence-based and patient-centered treatment planning.

2. Materials and methods

2.1. Study Design

This study employed a review article methodology following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The primary objective was to compare long-term treatment outcomes and relapse tendencies among adult patients with protrusive malocclusion treated using orthodontic-only modalities versus combined orthodontic–orthognathic surgical approaches. The review focused on evaluating skeletal stability, dental stability, relapse frequency, condylar changes, and long-term treatment predictability.

2.2. Search Strategy

A comprehensive search was conducted across three major electronic databases: PubMed, ScienceDirect, and Google Scholar. Relevant peer-reviewed articles published between 2015 and 2025 were screened. The search incorporated combinations of the following keywords and Boolean operators:

- “orthognathic surgery” AND “long-term stability”
- “adult malocclusion” AND “protrusion”
- “skeletal Class II” OR “skeletal Class III”
- “orthodontic camouflage”
- “relapse” OR “post-treatment stability”

- "condylar remodeling" AND "adult orthodontics"

The search was restricted to English-language full-text publications.

2.3. Inclusion Criteria

Studies were included if they met the following requirements:

- Adult patients (≥18 years) diagnosed with skeletal protrusive malocclusion (Class II or Class III).
- Research evaluating long-term outcomes (minimum 1-year follow-up) after either orthodontic-only or orthodontic–orthognathic surgical treatment.
- Studies reporting at least one of the following:
    - Skeletal or dental stability
    - Relapse magnitude
    - Hard-tissue remodeling
    - Condylar positional changes or tmj-related outcomes
- Study designs including randomized controlled trials, prospective or retrospective cohort studies, or systematic reviews.
- Articles published between 2015–2025 in peer-reviewed journals.

2.4. Exclusion Criteria

The following studies were excluded:

- Case reports, reviews without extractable outcome data, letters, conference abstracts, or commentaries.
- Studies involving adolescents or mixed dentition.
- Studies without measurable outcomes on relapse, stability, or long-term follow-up.
- Duplicate publications or non-peer-reviewed sources.

2.5. Study Selection

The study selection process followed the updated PRISMA flow framework. A total of 152 records were identified from all databases. After removal of duplicates, title screening, and abstract assessment, 25 studies remained for full-text evaluation. Following application of eligibility criteria, 5 studies met all inclusion standards and were included in the final synthesis. The complete identification and screening pathway is illustrated in (Figure 1).

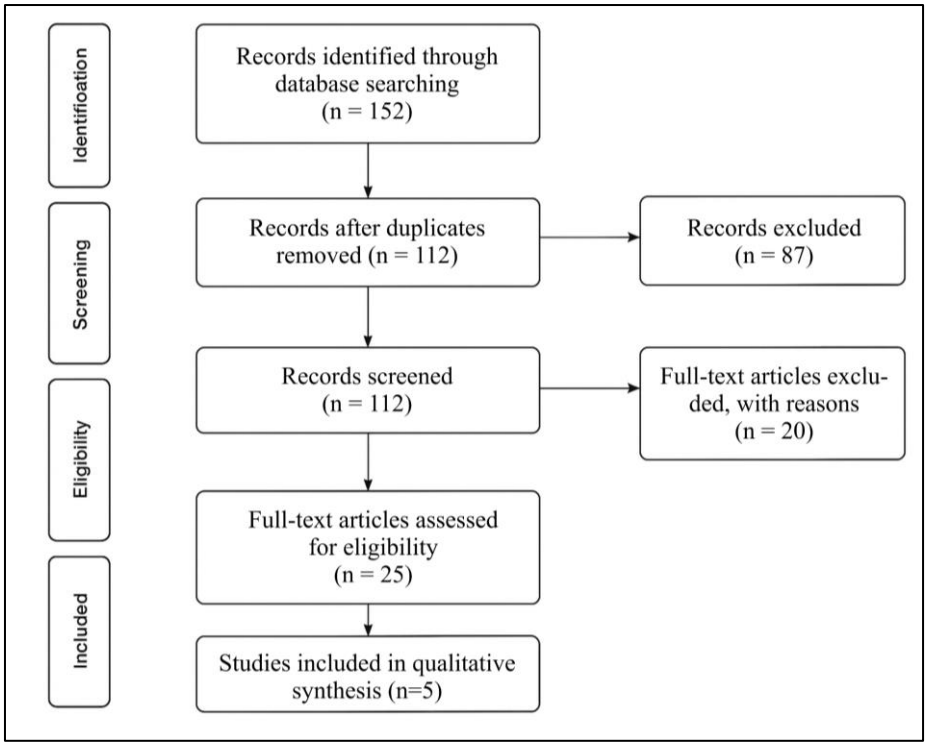

Figure 1 PRISMA flow diagram of the study selection process.

2.6. Data Extraction

Two reviewers independently extracted relevant data to ensure accuracy. Extracted variables included:

- Type of protrusive malocclusion (Class II or Class III)
- Treatment modality (orthodontic-only vs. orthodontic–orthognathic surgery)
- Type of surgical procedure (e.g., counterclockwise mandibular rotation, maxillomandibular advancement)
- Follow-up duration
- Measured outcomes: skeletal/dental stability, relapse magnitude, condylar changes
- Reported complications
- Quantitative values including SNA, SNB, ANB changes, mandibular plane angle (MPA), or occlusal relationships

2.7. Data Synthesis

Extracted data were tabulated for comparative interpretation. A narrative synthesis was used to integrate findings due to heterogeneity in study design, measurement methods, and outcome variables. Special emphasis was placed on relapse trends, condylar adaptation, and differences in long-term stability between surgical and non-surgical modalities.

3. Results and discussion

A total of five studies met the inclusion criteria and were analyzed to compare long-term outcomes and relapse risks in adults undergoing treatment for protrusive or skeletal malocclusion through either orthodontic-only approaches or combined orthodontic–orthognathic management. Across the included literature, orthognathic surgery groups consistently demonstrated superior skeletal stability, reduced relapse, and more predictable long-term changes, while orthodontic camouflage or non-surgical modalities showed variable stability with greater susceptibility to relapse due to dentoalveolar compensation. The studies also differed in follow-up duration, ranging from 2 years to over 10 years, allowing evaluation of both short-term and long-term post-treatment changes, including condylar remodeling, rotational stability, and vertical dimension control. Table 1 summarizes the extracted data, including sample characteristics, treatment modalities, retention protocols, and measured relapse outcomes.

Table 1 Summary of included studies on long-term stability and relapse in adult protrusive / skeletal malocclusions.

No	Study	Sample & Skeletal Type	Treatment Modality	Follow-up Duration	Key Outcomes	Relapse / Stability Findings
1	Mulier et al., 2021	Adults, Class II & III surgical cases	Orthognathic surgery + orthodontics	1–10 years	High skeletal accuracy and dental correction	Minimal relapse in sagittal dimension; mild transverse relapse reported
2	Romero et al., 2020	Adults with Class III	Bimaxillary or mandibular surgery	≥3 years	Significant improvement in maxillo-mandibular relationship	Mild mandibular forward relapse; condylar remodeling observed
3	Brandtner et al., 2015	Class II adults with transverse problems	Maxillomandibular surgery	2–5 years	Good inter-arch correction and transverse control	Stable transverse outcomes; slight relapse in occlusal cant
4	Wang et al., 2022	Class II high-angle adults	Orthodontic intrusion + CCW mandibular rotation	10 years	Maintained vertical reduction and bite closure	Stable CCW rotation; minimal vertical relapse
5	Tian et al., 2023	Class II hyperdivergent adults	Camouflage vs Orthognathic surgery	2–3 years	Surgery superior in condylar stability; camouflage produced compensatory changes	Camouflage group had condylar resorption risk and more relapse

The analysis of the five included studies demonstrates consistent differences in long-term outcomes between orthodontic-only treatment and combined orthodontic–orthognathic surgical approaches in adult protrusive and skeletal malocclusion. Across all articles, orthognathic surgery was repeatedly associated with superior skeletal stability, predictable postoperative adaptation, and lower relapse rates, particularly in the sagittal plane where adult cases often present with pronounced skeletal discrepancies. Mulier et al. (2021) showed that surgical repositioning of the maxillomandibular complex resulted in highly stable long-term dental and skeletal relationships, with only minor late transverse shifts that were considered physiologic remodeling rather than true relapse [8]. These findings align closely with the results of Romero et al. (2020), who reported that adults with Class III deformities experienced significant skeletal improvement after surgery, accompanied by only mild forward mandibular drift during follow-up that did not compromise functional or esthetic outcomes [1]. Together, these studies suggest that correcting the skeletal foundation, rather than relying on dentoalveolar compensation, remains the most predictable approach for long-term stability in adults.

Further evidence comes from Brandtner et al. (2015), who demonstrated that maxillomandibular surgical correction provided durable transverse stability even in complex multidimensional deformities [10]. Although a slight relapse in occlusal cant occurred, it was small and clinically insignificant, reinforcing the view that surgical expansion and three-dimensional skeletal repositioning are more stable in adults than orthodontic camouflage. In contrast, non-surgical approaches showed more varied outcomes. The 10-year study by Wang et al. (2022) revealed that counterclockwise mandibular rotation achieved through miniscrew-assisted intrusion could remain remarkably stable in high-angle Class II patients, highlighting that when skeletal anchorage and precise biomechanics are used, non-surgical vertical correction may achieve stability comparable to surgery in specific cases [11]. However, this stability is case-dependent and not generalizable to protrusive malocclusions with severe sagittal discrepancies.

The clearest contrast emerged in Tian et al. (2023), who directly compared orthodontic camouflage and orthognathic surgery in hyperdivergent Class II adults with TMJ osteoarthrosis [12]. The camouflage group exhibited significant risks of condylar remodeling, joint resorption, and sagittal relapse due to excessive dental compensation and the persistence of skeletal imbalance. Meanwhile, surgical correction provided superior condylar stability and functional improvement, emphasizing that camouflage treatment in adult skeletal cases may increase biomechanical strain on the TMJ and jeopardize long-term stability. Collectively, the evidence across all studies supports that orthodontic camouflage may be appropriate for mild skeletal discrepancies, but attempting to camouflage moderate-to-severe protrusive or hyperdivergent deformities often leads to greater long-term instability, compensatory dental movements, and a heightened risk of relapse.

Retention protocols also influenced outcomes. Studies on retention consistently emphasize that adults exhibit stronger periodontal fiber memory and reduced bone adaptability, making long-term or permanent retention essential regardless of treatment modality [2, 3, 6, 7, 13]. However, the clinical need for strict retention appears greater in camouflage cases because the teeth are placed in a compensated position that inherently carries a higher relapse tendency. Surgical cases, in contrast, benefit from post-surgical soft tissue and muscular adaptation, which enhances stability even if minor skeletal drift occurs.

Despite the overall strength of the evidence, several limitations across the included studies must be acknowledged. The sample sizes were relatively small in some trials, and heterogeneity existed in measurement methods, retention strategies, surgical techniques, and follow-up durations. Many studies lacked randomized controlled designs, limiting the ability to establish causality. Additionally, long-term condylar adaptation was variably reported, and few studies evaluated the influence of neuromuscular factors, airway changes, or tongue posture on relapse. Only limited research directly compared camouflage and surgical treatment in equivalent patient populations, indicating a need for standardized comparative trials. Future research should therefore include larger multi-center cohorts, long-term RCTs comparing camouflage versus surgery, advanced imaging (CBCT) to track 3D skeletal changes, and evaluations of functional parameters such as airway resistance, muscle adaptation, and TMJ biomechanics.

Overall, the synthesized evidence reveals that skeletal correction through orthognathic surgery provides the most stable and predictable long-term outcomes for adults with significant protrusive or skeletal discrepancies, whereas orthodontic camouflage remains appropriate only for mild cases and carries a higher risk of relapse, TMJ overload, and dentoalveolar instability. These findings highlight the importance of individualized diagnosis, realistic treatment planning, and long-term retention strategies tailored to the unique biomechanical limitations of adult patients.

4. Conclusion

Long-term stability in adult protrusive malocclusion depends on treatment modality and skeletal severity. Orthognathic surgery consistently provides superior skeletal correction, reduced relapse, and improved condylar stability, allowing harmonious neuromuscular and soft-tissue adaptation. Orthodontic camouflage is effective for mild-to-moderate cases but carries higher relapse risk, particularly with excessive dental compensation and TMJ vulnerability. Successful outcomes require individualized diagnosis, careful biomechanical planning, vertical control, and long-term retention. Surgical approaches should be prioritized for moderate-to-severe protrusions, while camouflage therapy is reserved for limited skeletal discrepancies to ensure lasting stability.

Compliance with ethical standards

Disclosure of conflict of interest

The author declares that there is no conflict of interest regarding the publication of this manuscript.

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