

# Zygomaticomaxillary Complex Fracture Repositioning Using Plates and Screws: Standard Techniques, Modifications, and Cost-Effectiveness Considerations

Iwan Setiawan Adji<sup>1</sup>, Zerlina Norberta Ramadhani<sup>2</sup>, Arum Widya Anantasya<sup>2</sup>, Ardhini Tyas Megaranti<sup>2</sup>, Gavin Editya Mukti<sup>2</sup>, Mohammad Alifiya Devano<sup>2</sup>

<sup>1</sup>Department of Otorhinolaryngology–Head and Neck Surgery, Kartini Regional General Hospital, Karanganyar, Indonesia; <sup>2</sup>Medical Professional Education Program, Universitas Muhammadiyah Surakarta, Sukoharjo, Indonesia

**Correspondence:** Zerlina Norberta Ramadhani: Kampus IV UMS, Jl. Ahmad Yani, Tromol Pos 1, Pabelan, Kartasura, Sukoharjo; norbertazr@gmail.com

## ABSTRACT

Zygomaticomaxillary complex (ZMC) fractures are among the most common midfacial injuries and may compromise both facial aesthetics and functional outcomes. Although traditional management recommends multipoint fixation to restore stability, emerging evidence suggests that minimal fixation may achieve comparable clinical results with greater procedural efficiency. This systematic review aims to evaluate the clinical outcomes and cost-effectiveness of one-point, two-point, and three-point fixation techniques in the management of ZMC fractures. This review was conducted following the PRISMA 2020 guidelines. A systematic search was performed in PubMed, ScienceDirect, Google Scholar, and ResearchGate. Eighteen studies evaluating plate-and-screw fixation techniques were included and analyzed qualitatively. Outcomes assessed included postoperative stability, facial symmetry, orbital function, complication rates, operative time, implant use, and overall treatment cost. One-point and two-point fixation demonstrated postoperative stability, facial symmetry, and orbital function comparable to three-point fixation when adequate anatomical reduction was achieved. Complication rates were low and showed no meaningful differences among fixation techniques. Minimal fixation was associated with shorter operative time, reduced implant use, and lower overall treatment costs. Efficiency gains were primarily attributed to decreased surgical duration and fewer required implants. Clinical outcomes were more strongly influenced by the quality of reduction and the strategic selection of fixation points than by the number of fixation sites. In conclusion, one-point and two-point fixation represent safe and effective alternatives to traditional multipoint fixation for selected ZMC fractures, offering optimal clinical outcomes while improving procedural efficiency and cost-effectiveness.

**Keywords:** zygomaticomaxillary complex fracture; internal fixation; one-point fixation; two-point fixation; cost-effectiveness

## INTRODUCTION

The zygomaticomaxillary complex (ZMC) represents a critical structural component of midfacial stability, function, and aesthetics. Anatomically, this complex separates the orbital cavity from the temporal fossa and maxillary sinus, while also contributing substantially to the lateral facial contour [1]. The zygoma functions as a major facial buttress that maintains facial width, supports craniofacial proportions, and transmits masticatory forces from the maxilla to the cranial base [1]. Despite its inherent structural strength, the prominent position of the zygoma makes it highly susceptible to traumatic impact, rendering ZMC fractures among the most frequently encountered midfacial injuries and a significant cause of both functional and aesthetic impairment [2]. Consequently, achieving accurate anatomical reduction accompanied by stable fixation remains the cornerstone of ZMC fracture management [2].

Structurally, the zygoma articulates with adjacent bones through several key buttresses, including the frontozygomatic suture, the zygomaticomaxillary buttress as part of the vertical facial buttress system, and the zygomaticotemporal junction forming the zygomatic arch [3]. These structural pillars play essential roles in maintaining midfacial projection, vertical facial height, and lateral facial stability [4]. Classical principles of ZMC fracture management emphasize that optimal stability is achieved through fixation at all three sites, ensuring restoration of anatomical alignment and continuity of the facial buttress system following reduction [4].

Each of the three fixation points contributes distinct biomechanical advantages [5]. Fixation at the frontozygomatic suture serves as a key control point for rotational stability of the zygoma, particularly against inferior and lateral displacement, and helps maintain the position of the lateral orbital rim [5]. Fixation at the zygomaticomaxillary buttress is crucial for restoring vertical midfacial height and re-establishing the vertical facial buttress essential for masticatory load transmission [6]. Meanwhile, fixation at the zygomatic arch or zygomaticotemporal region preserves lateral facial projection and prevents posterior displacement of the zygomatic fragment, which could otherwise alter facial width [6].

However, three-point fixation is not always mandatory in clinical practice [7]. Several studies have reported that in cases where anatomical reduction is adequately achieved, two-point fixation can yield clinical outcomes comparable to three-point fixation in terms of stability, function, and aesthetics [7]. Minimal fixation techniques also offer advantages such as shorter operative time, reduced soft-tissue trauma, and decreased use of internal fixation hardware [7]. The issue becomes more complex in settings with limited resources and financial constraints [8]. In many healthcare facilities, particularly in low- and middle-income countries, the availability of plates and screws is often restricted, making ideal multipoint fixation impractical [8]. Under such circumstances, surgeons may consider one-point fixation as an alternative, although concerns remain regarding postoperative stability and the risk of fragment displacement [8].

This situation raises an important question regarding which fixation point provides the greatest biomechanical benefit when the number of fixation sites must be minimized [9]. Some literature highlights the frontozygomatic suture as the key point for controlling zygomatic rotation, while others emphasize the zygomaticomaxillary buttress for maintaining midfacial height and projection [9]. To date, no consensus has been reached regarding the optimal minimal number and location of fixation points for ZMC fractures [9]. Beyond biomechanical considerations, fixation strategy selection is closely linked to healthcare efficiency, including operative duration, complication risk, and overall treatment cost [9]. In resource-limited health systems such as Indonesia's National Health Insurance (BPJS), conservative yet safe and effective fixation approaches are particularly relevant [9].

Therefore, this literature review aims to systematically and critically evaluate the available scientific evidence comparing clinical outcomes of one-, two-, and three-point fixation in ZMC fractures; to examine biomechanical considerations in selecting minimal fixation points; to assess the influence of fixation number and location on stability, complications, and aesthetic outcomes; and to explore the relevance of minimal fixation

strategies within the context of resource-limited healthcare systems. This review is expected to provide a rational scientific basis for clinicians in determining effective, safe, and context-appropriate management strategies for ZMC fractures.

## METHODS

This study is a systematic review conducted through a structured and comprehensive search of scientific literature based on predefined inclusion and exclusion criteria. The study was developed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Figure 1), with the aim of examining and analyzing the scientific evidence related to the reduction and internal fixation of zygomaticomaxillary complex (ZMC) fractures using plate-and-screw systems, including both standard techniques and various modifications in the number and location of fixation points. In addition to evaluating clinical effectiveness and postoperative stability, this review also considers the cost implications associated with internal fixation systems, particularly within healthcare settings characterized by limited resources.

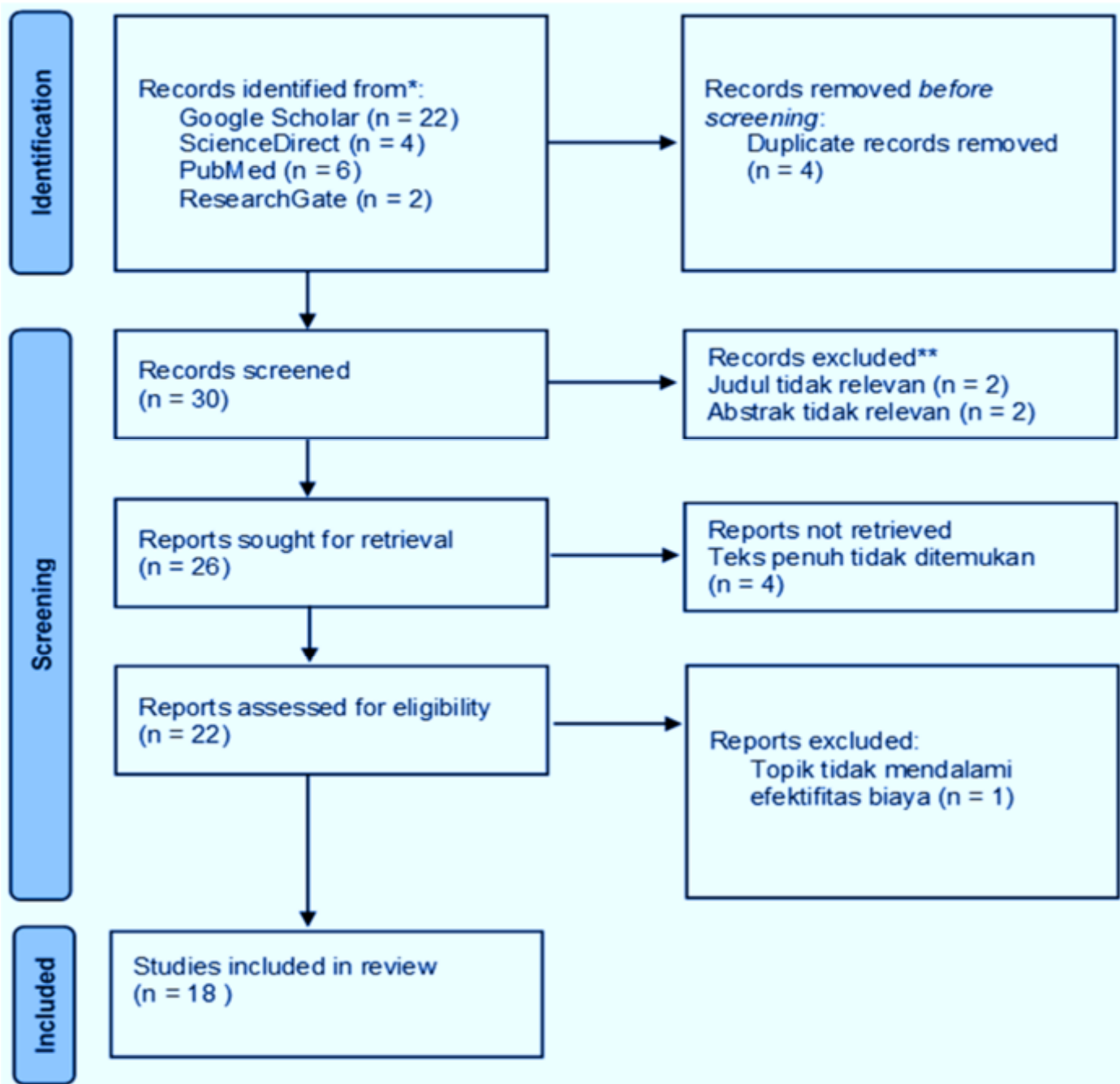


Figure 1. PRISMA flow diagram for article selection

A systematic literature search was performed in PubMed, ScienceDirect, ResearchGate, and Google Scholar on 25 December 2025 using a combination of the following keywords: "zygomaticomaxillary complex fracture", "zygoma fracture", "open reduction internal fixation", "plate and screw fixation", "titanium plate", "one-point fixation", "two-point fixation", "three-point fixation", "cost effectiveness", and "clinical outcome", arranged using Boolean operators AND and OR. Articles were included if they were published in English or Indonesian, discussed ZMC fractures managed with anatomical reduction and internal fixation using plates and screws, reported standard or modified one-, two-, or three-point fixation techniques, and provided clinical data or cost-related considerations. Eligible publication types included original research, case reports, case series, clinical guidelines, and relevant review articles, with no restrictions on publication year.

Articles were excluded if full-text access was unavailable, if the study did not involve the zygomaticomaxillary complex, if it was an experimental animal study, or if it was irrelevant to the study question. The selection process involved title and abstract screening, followed by full-text

assessment and removal of duplicates using a reference manager. All stages of the selection process adhered to PRISMA principles to ensure transparency, methodological rigor, and validity of the review.

Article selection was conducted by two independent reviewers through systematic screening of titles, abstracts, and full texts. Discrepancies were resolved through discussion, with a third reviewer consulted when necessary. Quality appraisal and risk-of-bias assessment were performed using tools appropriate to each study design, including the Critical Appraisal Skills Programme (CASP), the Newcastle–Ottawa Scale, and ROBINS-I. The results of these appraisals were incorporated into the interpretation of the study findings to ensure a robust and evidence-based synthesis.

## RESULTS

From the full selection process, a total of 18 articles met all predefined inclusion criteria and were subsequently included for in-depth analysis within this systematic review. The accepted studies represent a heterogeneous body of evidence, encompassing variations in study design, methodological rigor, and clinical context, all of which examined the management of zygomaticomaxillary complex fractures using internal fixation with plates and screws. This diversity reflects the wide range of surgical approaches and fixation strategies applied in clinical practice, including differences in the number and anatomical location of fixation points, implant selection, and operative techniques. Table 1 provides a detailed summary of the characteristics and distinctions among the included studies, highlighting variations in fixation methods, clinical outcomes assessed, and contextual considerations relevant to the treatment of zygomaticomaxillary complex fractures.

Table 1. Characteristics of studies on zygomaticomaxillary complex fractures

Authors (year)	Location	Design	Sample	Technique	Points	Outcomes
El-Sayed et al. (2024) [1]	Egypt	Review	–	ORIF	Multipoint	Postoperative stability is primarily achieved through restoration of the facial buttress system rather than the number of fixation points alone.
Sharma et al. (2023) [2]	India	Retrospective	28	ORIF	2	Two-point fixation demonstrated greater efficiency in implant utilization without compromising clinical outcomes.
Sakkas et al. (2025) [5]	Germany	Observational	48	ORIF	1 vs multipoint	Minimal fixation reduced implant requirements without increasing complication rates.
Widiarni et al. (2021) [6]	Indonesia	Case series	2	ORIF	2–3	Two-point fixation required fewer implants and showed potential for reducing treatment costs.
Gawande et al. (2021) [7]	India	Prospective	30	ORIF plate & screw	2 vs 3	Two-point fixation provided stability and clinical outcomes comparable to three-point fixation, with superior cost efficiency.
Solanki et al. (2024) [8]	India	Case report	1	ORIF	1	Single-point fixation using one plate and screw significantly reduced procedural costs.
Nainoor & Prashanth (2024) [9]	India	Systematic review	12	ORIF	2 vs 3	No strong evidence supports the cost-effectiveness of multipoint fixation over minimal fixation.
Ellis & Perez (2021) [10]	USA	Review	–	ORIF	Multipoint	Multipoint fixation offers theoretical biomechanical advantages; however, limited fixation may be considered to reduce material use without compromising outcomes.
Ahmed et al. (2025) [11]	Egypt	Retrospective	33	ORIF	2	Two-point fixation provided an optimal balance between clinical effectiveness and cost.
Kim et al. (2023) [12]	Korea	Prospective	36	ORIF	2 vs 3	Facial symmetry was comparable between two- and three-point fixation; no cost justification was found for additional fixation points.
Markiewicz et al. (2023) [13]	USA	Review	–	ORIF	Multipoint	Emphasized the importance of key facial buttresses; strategic fixation at essential points may reduce the need for multipoint fixation.
Klotch et al. (2022) [14]	Germany	Observational	40	ORIF	2	Adequate postoperative stability achieved with two-point fixation, with lower costs compared to multipoint fixation.
López et al. (2024) [15]	Spain	Prospective	29	ORIF	2	Two-point fixation was more efficient in terms of operative time and implant use.
Al-Qurayshi et al. (2022) [16]	USA	Retrospective	84	ORIF	Variable	No significant cost advantage was observed for multipoint fixation in uncomplicated cases.
Chen et al. (2024) [17]	China	Observational	41	ORIF	2–3	Accuracy of reduction was the primary determinant of outcome; additional plates did not yield proportional clinical benefits relative to cost.
Batra et al. (2023) [18]	India	Prospective	34	ORIF	1 vs 2	One- to two-point fixation provided adequate stability and was more cost-effective than multipoint fixation.
Bede et al. (2022) [19]	UK	Retrospective	52	ORIF	1–3	Minimal fixation effectively reduced implant consumption and operative time.
Rahman et al. (2024) [20]	Bangladesh	Retrospective	26	ORIF	2	Two-point fixation produced satisfactory aesthetic outcomes and was more feasible for resource-limited healthcare settings.

The evidence comparing standard, modified, and minimal internal fixation techniques for zygomaticomaxillary complex fractures using plate-and-screw systems is summarized in Table 2.

Table 2. Study outcomes and limitations

No.	Aspect	Summary of Evidence from Included Studies	Limitations of Evidence
1	Postoperative bone stability	One- or two-point fixation provides postoperative bone stability comparable to three-point fixation when anatomical reduction is adequately achieved.	Most studies are observational with limited randomized controlled trials.
2	Facial aesthetic outcomes	Facial symmetry and malar projection are generally satisfactory, with no meaningful differences across different numbers of fixation points.	Aesthetic assessment is often subjective and lacks standardized measurement scales.
3	Orbital function	Rates of residual diplopia and postoperative enophthalmos are low and do not differ significantly between fixation techniques.	Follow-up duration varies widely and is relatively short in several studies.
4	Postoperative infection	Infection rates are low and do not increase with minimal fixation approaches.	Definitions and reporting methods for infection are inconsistent across studies.
5	Malposition or fragment displacement	Malposition is uncommon and is more strongly associated with the quality of initial reduction than with the number of fixation points.	Fracture severity is not consistently classified across studies.
6	Need for reoperation	Reoperation due to instability or fixation failure is rare and shows no significant difference between fixation groups.	Several studies have small sample sizes.
7	Operative duration	One- to two-point fixation consistently reduces operative time.	Not all studies provide quantitative data on operative duration.
8	Nerve-related complications	Infraorbital paresthesia is typically transient and resolves spontaneously.	Nerve function is often assessed clinically without objective testing.
9	Cost-effectiveness	Reduced implant use and shorter operative time improve overall cost-effectiveness of minimal fixation.	Systematic and structured cost analyses (e.g., cost-effectiveness, cost-benefit, cost-utility) are rarely performed.
10	Clinical applicability	Minimal fixation is safe and effective for selected ZMC fractures with good reduction quality.	Findings may not apply to comminuted fractures or severe dislocations.

## DISCUSSION

The findings of this literature review indicate that two-point fixation in the management of zygomaticomaxillary complex (ZMC) fractures provides clinically reliable postoperative stability without meaningful differences when compared with traditional three-point fixation [1]. This outcome aligns with the fundamental principles of ZMC fracture management, which emphasize the importance of achieving accurate anatomical reduction and adequate stabilization rather than relying solely on the number of fixation points [10]. Several clinical reports consistently support the notion that successful treatment of ZMC fractures is determined primarily by the precision of three-dimensional zygomatic repositioning rather than by routine or aggressive multipoint fixation strategies [4].

The absence of significant differences in postoperative bone stability between two- and three-point fixation observed in this review is consistent with multiple clinical studies reporting similar outcomes in ZMC fractures without severe displacement or comminution [6]. These findings suggest that in stable fracture patterns, two-point fixation is sufficient to maintain zygomatic alignment throughout the healing process [10].

Regarding facial aesthetics, the literature review demonstrates no meaningful differences in malar symmetry or midfacial contour between the two fixation techniques [11]. This observation is consistent with evidence indicating that aesthetic outcomes are more closely associated with the accuracy of zygomatic reduction than with the number of plates and screws used [11]. Consequently, increasing the number of fixation points does not inherently improve aesthetic results [12].

In terms of orbital function, the review shows satisfactory outcomes with two-point fixation, with no increase in residual diplopia or postoperative enophthalmos [5]. This finding supports previous reports that orbital function is influenced more by the precision of orbital wall and zygomatic complex repositioning than by the number of fixation points applied [10].

Biomechanically, although multipoint fixation theoretically provides a more rigid construct and greater resistance to rotational forces [4], the literature review indicates that these theoretical advantages do not consistently translate into superior clinical outcomes [13]. This reinforces the concept that the primary role of fixation is to maintain an already accurate anatomical reduction rather than to compensate for inadequate repositioning [13].

The review also highlights improved operative efficiency with two-point fixation compared with three-point fixation [14]. This is consistent with reports showing that reducing the number of fixation points contributes to shorter operative times and more efficient use of surgical materials [15]. Such efficiency is particularly valuable in high-volume clinical settings where operative time is a critical resource [15].

From an economic perspective, the literature review demonstrates that two-point fixation is more cost-effective without increasing postoperative complications [16]. This aligns with studies reporting that multipoint fixation does not offer significant cost advantages in uncomplicated ZMC fractures [17]. Therefore, routine use of three-point fixation in all ZMC cases may unnecessarily increase healthcare costs without providing additional clinical benefit [17].

The review further supports the use of minimal fixation approaches—including one- or two-point fixation—in selected cases with good intrinsic stability [18]. Several reports indicate that accurate zygomatic reduction can be maintained even with a single fixation point when applied at a biomechanically strategic location [8]. However, such approaches must be selected carefully and based on comprehensive clinical evaluation [19].

In resource-limited healthcare settings, the findings of this review reinforce the practicality and rationality of two-point fixation as a balanced strategy [17]. This approach offers an optimal combination of clinical stability, aesthetic and functional outcomes, and improved efficiency in both cost and operative time [18]. These considerations are particularly relevant in developing countries and healthcare systems with constrained financial resources [20].

Nevertheless, the findings of this review cannot be generalized to all ZMC fracture patterns [1]. The literature consistently emphasizes that fractures with severe comminution, significant displacement, multidirectional instability, or complex orbital involvement still require multipoint fixation to ensure optimal anatomical restoration and postoperative stability [4].

Overall, the findings of this literature review support a paradigm shift in ZMC fracture management—from routine multipoint fixation toward selective fixation tailored to fracture pattern and individual biomechanical requirements [9]. This approach enables safe and effective clinical outcomes while optimizing resource utilization without compromising stability, function, or facial aesthetics [20].

Despite these insights, the review has several limitations. First, there is considerable variability in study design, patient characteristics, and fixation methods among the included studies, limiting direct comparison and generalizability. Second, the number of high-quality studies remains limited, with several exhibiting moderate to high risk of bias based on appraisal results. Third, publication bias cannot be fully excluded, as only accessible published articles were analyzed. Therefore, these findings should be interpreted with caution, and further primary studies with stronger methodological rigor are needed to strengthen the evidence base.

## CONCLUSION

This review demonstrates that open reduction and internal fixation of zygomaticomaxillary complex (ZMC) fractures does not universally require multipoint fixation to achieve optimal clinical outcomes. The majority of available evidence shows that one- or two-point fixation, when combined with precise anatomical reduction and strategically selected fixation sites, can provide postoperative bone stability, satisfactory facial aesthetics, and preserved orbital function comparable to three-point fixation. Single-point fixation at the frontozygomatic suture may be sufficient in selected cases, given its biomechanical role as a strong lateral facial buttress capable of controlling zygomatic rotation and translation. Overall, the success of ZMC fracture management is determined more by the quality of reduction and restoration of the facial buttress system than by the number of fixation points applied. Minimal fixation approaches also consistently demonstrate shorter operative times, reduced implant use, and improved cost-efficiency without increasing postoperative complications, making them a safe, effective, and rational alternative—particularly in resource-limited healthcare settings. Nevertheless, because much of the current evidence is derived from observational studies, larger prospective investigations with long-term follow-up are needed to establish more definitive clinical recommendations.

## Ethical consideration, competing interest and source of funding

-This study is a secondary analysis of previously published literature and did not involve direct interaction with human participants. All included studies reported approval from their respective ethics committees and documented informed consent from patients or guardians. Throughout the review process, principles of academic integrity, transparency, and accurate reporting were upheld.

-There is no conflict of interest related to this publication.

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