

Does Delay in Definitive Treatment Affect Complication Rates Following Maxillofacial Fractures? A Retrospective Cohort Study

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Abstract

Purpose

The optimal timing of surgical management for maxillofacial fractures remains controversial. This study evaluated the association between surgical delay and postoperative outcomes following operative management of maxillofacial fractures.

Methods

A retrospective cohort study was conducted on 216 patients who underwent operative management of maxillofacial fractures between January 2020 and December 2024. Patients were categorized into early (< 72 h) and delayed (> 72 h) treatment groups. Demographic, clinical, surgical, and follow-up data were analyzed. Associations between treatment timing and outcomes were assessed using chi-square test, Fisher's exact test, Mann–Whitney U test, and binary logistic regression.

Results

The median interval between injury and surgery was 12 days (IQR 6–17 days). Delayed treatment was observed in 192 (88.9%) patients. Postoperative infection was significantly more frequent in the delayed group than in the early group (24.5% vs. 4.2%; $P = 0.024$). Overall postoperative complications were also significantly higher among delayed cases (55.2% vs. 25.0%; $P = 0.005$), as were complications at the 1-week follow-up (33.9% vs. 12.5%; $P = 0.034$). Delayed treatment was associated with a significantly increased risk of postoperative complications among mandibular fractures (OR 6.15, 95% CI 1.60–23.60; $P = 0.008$).

Conclusion

Delayed surgical management was associated with increased rates of postoperative infection, overall postoperative complications, and early follow-up complications. Early definitive treatment, particularly for mandibular fractures, may reduce postoperative morbidity and improve clinical outcomes.

1. Introduction

Maxillofacial fractures represent a significant proportion of trauma-related hospital admissions and remain an important cause of functional and aesthetic morbidity worldwide. These injuries commonly result from road traffic accidents, interpersonal violence, falls, and sports-related trauma, involving structures such as the mandible, maxilla, zygomaticomaxillary complex, orbit, and naso-orbito-ethmoidal region. Disruption of the facial skeleton may compromise occlusion, mastication, speech, vision, airway patency, and facial aesthetics, thereby adversely affecting patient quality of life[1, 2].

The primary goals of maxillofacial fracture management are restoration of facial form and function, re-establishment of occlusion, and prevention of postoperative complications [3]. Open reduction and

internal fixation (ORIF) is widely accepted as the standard treatment modality for displaced facial fractures due to its ability to provide stable fixation and predictable outcomes. However, postoperative complications including infection, malocclusion, wound dehiscence, trismus, sensory disturbances, hardware exposure, and delayed union continue to pose considerable clinical challenges and may contribute to prolonged hospitalization and increased healthcare burden[4].

Among the factors influencing postoperative outcomes, the timing of surgical intervention remains controversial. Early operative management is believed to facilitate anatomical reduction before the onset of fibrosis, edema, and early callus formation, potentially reducing morbidity and improving functional recovery. Conversely, delayed intervention is often unavoidable due to associated systemic injuries, polytrauma, delayed referral, medical comorbidities, or logistical constraints[4, 5].

Current evidence regarding the effect of surgical delay on postoperative outcomes remains inconclusive. Lander et al.[5] reported an increased risk of malunion and non-union with delayed treatment of mandibular fractures, whereas James et al.[6] found no significant association between treatment delay and postoperative complications. Similarly, a recent systematic review by Chen et al.[7] concluded that existing evidence comparing early and delayed fixation in maxillofacial trauma remains heterogeneous and insufficient to establish definitive clinical recommendations.

Furthermore, most previous studies have focused on isolated mandibular fractures rather than evaluating maxillofacial trauma comprehensively. Variability in study design, definitions of surgical delay, and outcome assessment further limits the generalizability of existing literature. Therefore, further investigation is warranted to clarify the independent association between surgical delay and postoperative complications following operative management of maxillofacial fractures.

The present retrospective cohort study was undertaken to evaluate the association between surgical delay and postoperative complications in patients undergoing operative management of maxillofacial fractures, while accounting for important confounding variables including age, sex, fracture type, open fracture status, and polytrauma.

2. Materials and methods

2.1 Study design and setting

This retrospective cohort study was conducted at a tertiary care referral centre between January 2023 and January 2026 following approval from the Institutional Ethics Committee (IEC/1697). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments.

2.2 Study population

The study included patients diagnosed with maxillofacial fractures who underwent surgical management during the study period. Eligible patients were required to have complete demographic, clinical, operative,

and follow-up records available in the institutional database. Surgical treatment primarily consisted of open reduction and internal fixation (ORIF).

Patients managed conservatively without surgical intervention, those with pathological fractures, and patients with incomplete medical records were excluded from the study. In addition, patients with severe systemic injuries or medical conditions independently affecting postoperative recovery and outcomes were also excluded to minimize confounding bias.

2.3 Exposure Variable

The primary exposure variable was the timing of surgical intervention, defined as the interval between injury and definitive surgical management. Based on this interval, patients were categorized into:

Early intervention group

surgery performed within 72 h of injury

Delayed intervention group

surgery performed after 72 h of injury

2.4 Data Collection and Outcome Measures

Data was collected retrospectively from patient case records, operation theatre registers, radiographic archives, and discharge summaries. Demographic and clinical variables recorded included age, sex, etiology of trauma, fracture type and anatomical site, presence of open fracture, associated polytrauma, time interval between injury and surgery, type of surgical procedure performed, postoperative complications, and length of hospital stay. Polytrauma was defined as the presence of significant associated injuries involving other body regions requiring multidisciplinary management or hospitalization.

The primary outcome measure was the occurrence of postoperative complications following operative management of maxillofacial fractures, including surgical site infection, malocclusion, neurosensory deficit, trismus, wound dehiscence, hardware exposure, delayed union, non-union, and the requirement for secondary surgical intervention. Surgical site infection was defined as the presence of purulent discharge, localized swelling, abscess formation, or the need for antibiotic escalation or surgical drainage. Malocclusion was defined as any postoperative disturbance of the pre-injury occlusal relationship requiring clinical correction. Neurosensory deficit referred to postoperative hypoesthesia, paraesthesia, or anaesthesia within the distribution of the affected sensory nerve. Trismus was defined as a maximum interincisal opening of < 35 mm. Wound dehiscence was defined as partial or complete separation of the surgical wound margins. Hardware exposure referred to clinical exposure of fixation hardware through the overlying soft tissues. Delayed union was defined as the absence of satisfactory clinical and/or radiographic evidence of fracture healing after 8 weeks, whereas non-union was defined

as failure of bony union by 12 weeks after treatment, with no evidence of progressive healing. Secondary surgical intervention was defined as any unplanned operative procedure performed to manage a postoperative complication or treatment failure. The secondary outcome measure was length of hospital stay, defined as the duration from hospital admission to discharge.

2.5 Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as median (interquartile range [IQR]) and range due to non-normal distribution, while categorical variables were presented as frequencies and percentages.

Fracture patterns and postoperative complications were analyzed using multiple-response analysis. Associations between treatment timing and categorical outcomes were assessed using the chi-square test or Fisher's exact test, as appropriate. The association between treatment timing and hospital stay was evaluated using the Mann–Whitney U test.

Binary logistic regression was used to assess the relationship between treatment timing and postoperative infection, with results reported as odds ratios (ORs) and 95% confidence intervals (CIs). Exploratory models further evaluated the effects of fracture site, surgical approach, and their interaction with treatment timing on infection risk. Model performance was assessed using Nagelkerke's pseudo- R^2 . A two-sided P value < 0.05 was considered statistically significant.

3. Results

3.1. Demographic Characteristics

The demographic characteristics of the study population are summarized in Table 1. A total of 216 patients were included, with a median age of 27 years (IQR, 21–37 years; range, 11–71 years). The 20–29-year age group constituted the largest proportion of the cohort, comprising 81 (37.5%) patients, followed by the 10–19-year and 30–39-year age groups, with 43 (19.9%) patients each. A marked male predominance was observed, with 183 (84.7%) male patients and 33 (15.3%) female patients (Table 1).

Table 1
Baseline demographic and clinical characteristics of the study cohort

Demographic variable	Category	N (%) / Median(Q1–Q3)
Age(years)/ Age group	Median(Q1–Q3)	27(21–37)
	Range	11–71
	10–19 years	43(19.9%)
	20–29 years	81(37.5%)
	30–39 years	43(19.9%)
	40–49 years	30(13.9%)
	50–59 years	17(7.9%)
	≥ 60 years	2(1%)
Gender	Male	183(84.7%)
	Female	33(15.3%)
ASA status	ASA I	203(94.0%)
	ASA II	13(6.0%)
Mode of injury	RTA	191(88.4%)
	Fall	17(7.9%)
	Physical assault	6(2.8%)
	Gunshot	2(0.9%)
Type of trauma	Isolated trauma	191(88.4%)
	Polytrauma	25(11.6%)

3.2. Etiology and baseline clinical characteristics

The etiological and baseline clinical characteristics of the study population are presented in Table 1. Most patients were classified as ASA I, accounting for 203 (94.0%) patients, while 13 (6.0%) patients were categorized as ASA II. Road traffic accidents were the predominant mechanism of injury, occurring in 191 (88.4%) patients, followed by falls in 17 (7.9%) patients. Physical assault and gunshot injuries were relatively uncommon, affecting 6 (2.8%) and 2 (0.9%) patients, respectively. The majority of patients presented with isolated maxillofacial trauma (191 [88.4%]), whereas 25 (11.6%) patients had associated polytrauma (Table 1).

3.3. Fracture Characteristics

The fracture characteristics of the study population are summarized in Table 2. Multiple fracture sites were observed in 136 (63.0%) patients, whereas 80 (37.0%) patients sustained a single fracture. Closed fractures were more common, occurring in 140 (64.8%) patients, compared with open fractures in 76 (35.2%).

Table 2
Anatomical distribution of
maxillofacial fracture patterns

Fracture pattern	N (%)
ZMC	83(38.4%)
Parasymphysis	61(28.2%)
Angle	31(14.4%)
Condyle	30(13.9%)
Subcondyle	22(10.2%)
Symphysis	21(9.7%)
Body	14(6.5%)
NOE	12(5.6%)
LeFort I	10(4.6%)
LeFort II	1(0.5%)
Zygoma	6(2.8%)
Orbital floor	6(2.8%)
Mandible	6(2.8%)
Zygomatic arch	5(2.3%)
Nasal	4(1.9%)
Palate	1(0.5%)
Panfacial	1(0.5%)

Mandibular fractures constituted the most frequently involved broad anatomical region, affecting 105 (48.6%) patients, followed by zygomatic fractures in 54 (25.0%) and panfacial fractures in 21 (9.7%) patients. Among individual fracture patterns, zygomaticomaxillary complex (ZMC) fractures were the most common, occurring in 83 (38.4%) patients, followed by parasymphysis fractures in 61 (28.2%). Angle, condyle, and subcondyle fractures were identified in 31 (14.4%), 30 (13.9%), and 22 (10.2%) patients, respectively. As multiple fracture sites could be present in the same patient, the cumulative percentages of individual fracture patterns exceeded 100% (Table 2, Fig. 1).

3.4. Fracture-Related Clinical Findings and Intraoperative Complications

The fracture-related clinical findings and intraoperative complications are presented in Table 3. Fracture displacement was observed in 203 (94.0%) patients, while occlusal discrepancy was present in 120 (55.6%) patients. Intraoperative complications occurred in 37 (17.1%) patients. Bleeding was the most frequently reported intraoperative complication, affecting 11 (5.1%) patients. No intraoperative complications were recorded in 19 (8.8%) patients (Table 3).

Table 3
Fracture characteristics, intraoperative complications, and surgical–perioperative characteristics of the study population

Variable	Category	N (%)
Displacement	Present	203(94.0%)
Occlusal discrepancy	Present	120(55.6%)
Intraoperative complication	Present	37(17.1%)
Type of intraoperative complication	Bleeding	11(5.1%)
	Other	186(86.1%)
	Nil	19(8.8%)
Timing interval(days)	Median(Q1–Q3)	12(6–17)
	Range	1–52
Duration of surgery(hours)	Median(Q1–Q3)	2.0(2.0–2.75)
	Range	0.5–6.0
Timing category	Early	24(11.1%)
	Delayed	192(88.9%)
Reason for delay	Late presentation	119(55.1%)
	OT availability	63(29.2%)
	Polytrauma stabilization	29(13.4%)
	NA	5(2.3%)
Type of surgery	ORIF	209(96.8%)
	Open	4(1.9%)
	Closed	3(1.4%)
Surgical approach	Intraoral	110(50.9%)
	Extraoral	78(36.1%)
	Intraoral + Extraoral	27(12.5%)
	Intranasal	1(0.5%)
Type of fixation	Miniplate	199(92.1%)
	Miniplate + screws	14(6.5%)
	Reconstruction plate	1(0.5%)

Variable	Category	N (%)
	Miniplate + orbital mesh	1(0.5%)
	Closed	1(0.5%)

3.5. Surgical and Perioperative Characteristics

The surgical and perioperative characteristics are summarized in Table 3. The median interval between injury and surgical treatment was 12 days (IQR, 6–17 days; range, 1–52 days). Delayed treatment was observed in 192 (88.9%) patients, with late presentation representing the most common reason for delay (119 [55.1%] patients). Open reduction and internal fixation (ORIF) were performed in 209 (96.8%) patients. The intraoral approach was the most frequently used surgical approach, accounting for 110 (50.9%) cases, while miniplate fixation was the predominant fixation method, used in 199 (92.1%) patients (Table 3).

3.6. Postoperative Complications

The distribution of postoperative complications is presented in Table 4. Nerve injury was the most common postoperative complication, occurring in 53 (47.3%) patients, followed by infection in 48 (42.9%) and trismus in 30 (26.8%) patients. Wound dehiscence was observed in 16 (14.3%) patients. Exposure, delayed union, and non-union were uncommon, each occurring in 3 (2.7%) patients. As multiple postoperative complications could occur in the same patient, the cumulative percentages exceeded 100% (Table 4, Fig. 2).

Table 4
Distribution of postoperative complications
following operative management of
maxillofacial fractures

Postoperative complication	N (%)
Nerve injury	53(47.3%)
Infection	48(42.9%)
Trismus	30(26.8%)
Wound dehiscence	16(14.3%)
Exposure	3(2.7%)
Delayed union	3(2.7%)
Non-union	3(2.7%)

3.7. Association Between Treatment Timing and Postoperative Complications

The association between treatment timing and postoperative complications is presented in Table 5. Postoperative infection occurred in 48 (22.2%) patients and was significantly more frequent in the delayed treatment group than in the early treatment group (47 [24.5%] vs. 1 [4.2%]; $P = 0.024$). Similarly, the overall rate of postoperative complications was significantly higher among patients undergoing delayed treatment (106 [55.2%]) compared with those treated early (6 [25.0%]; $P = 0.005$).

Table 5
Association between treatment timing and postoperative complications following operative management of maxillofacial fractures.

Presence of Postoperative complication	Early(n = 24)	Delayed(n = 192)	Total(n = 216)	Test statistic	P value
Infection ^a	1(4.2%)	47(24.5%)	48(22.2%)	$\chi^2=5.093$	0.024*
Nerve injury ^a	4(16.7%)	49(25.5%)	53(24.5%)	$\chi^2=0.903$	0.342
Trismus ^a	2(8.3%)	28(14.6%)	30(13.9%)	—	0.542
Wound dehiscence ^a	1(4.2%)	15(7.8%)	16(7.4%)	—	> 0.99
Exposure ^a	0(0.0%)	3(1.6%)	3(1.4%)	—	> 0.99
Delayed union ^a	0(0.0%)	3(1.6%)	3(1.4%)	—	> 0.99
Non-union ^a	0(0.0%)	3(1.6%)	3(1.4%)	—	> 0.99
Overall postoperative complication ^a	6(25.0%)	106(55.2%)	112(51.9%)	$\chi^2=7.798$	0.005*
a: Analyzed using Chi-square test; b: Analyzed using Fisher's exact test					
*: statistically significant ($P < 0.05$)					

Nerve injury was observed in 53 (24.5%) patients and trismus in 30 (13.9%) patients; however, neither complication showed a significant association with treatment timing ($P = 0.342$ and $P = 0.542$, respectively). No significant associations were identified between treatment timing and wound dehiscence, exposure, delayed union, or non-union (all $P > 0.99$) (Table 5).

3.8. Association Between Treatment Timing and Follow-up Outcomes

The association between treatment timing and follow-up outcomes is presented in Table 6. A significant association was observed between treatment timing and the occurrence of complications at the 1-week follow-up, with complications being more frequent in the delayed treatment group than in the early treatment group (65 [33.9%] vs. 3 [12.5%]; $P = 0.034$).

Table 6
Association between treatment timing and follow-up outcomes among study participants

Variable	Early(n = 24)	Delayed(n = 192)	Total(n = 216)	Test statistic	P value
Need for second surgery ^a	1(4.2%)	24(12.5%)	25(11.6%)	—	0.324
Presence of 1-week follow-up complication ^a	3(12.5%)	65(33.9%)	68(31.5%)	$\chi^2=4.510$	0.034*
Presence of 6-week follow-up complication ^a	5(20.8%)	61(31.8%)	66(30.6%)	$\chi^2=1.203$	0.273
Additional surgery needed ^a	1(4.2%)	41(21.4%)	42(19.4%)	—	0.054
a: Analyzed using Chi-square test; b: Analyzed using Fisher's exact test					
*: statistically significant ($P < 0.05$)					

No significant associations were identified between treatment timing and the need for a second surgery (24 [12.5%] vs. 1 [4.2%]; $P = 0.324$), complications at the 6-week follow-up (61 [31.8%] vs. 5 [20.8%]; $P = 0.273$), or the requirement for additional surgery (41 [21.4%] vs. 1 [4.2%]; $P = 0.054$) (Table 6).

3.9. Association Between Treatment Timing and Length of Hospital Stay

The association between treatment timing and duration of hospital stay is presented in Table 7. The median length of hospital stay was 8.5 days (IQR, 7.0–13.75 days) in the early treatment group and 10.0 days (IQR, 7.0–13.0 days) in the delayed treatment group. No significant difference in hospital stay was observed between the two groups (Mann–Whitney $U = 2017$, $P = 0.319$). The distribution of hospital stay according to treatment timing is illustrated in Fig. 3

Table 7
Association between timing category and duration of hospital stay among study participants

Timing category	Median (Q1–Q3)	Range	Mann–Whitney statistic	<i>P</i> value
Early	8.5 (7.0–13.75)	4–18	2017	0.319
Delayed	10.0 (7.0–13.0)	2–49		
Q1: first quartile; Q3: third quartile				

3.10. Logistic Regression Analysis of Factors Associated with Postoperative Complications

The results of the binary logistic regression analyses are presented in Table 8. Fracture site, surgical approach, and treatment timing were not significantly associated with postoperative complications in

the overall cohort (all $P > 0.05$). Likewise, delayed treatment was not significantly associated with the development of malocclusion (OR 0.37, 95% CI 0.04–3.66; $P = 0.391$).

Table 8
Binary logistic regression analyses of factors associated with postoperative complications and malocclusion

Analysis	Predictor	OR (95% CI)	P value
Fracture site	Maxilla	0.38 (0.07–2.14)	0.269
Mandibular fractures	Delayed treatment	6.15 (1.60–23.60)	0.008*
Surgical approach	Intraoral	0.62 (0.35–1.11)	0.110
Extraoral approach	Delayed treatment	2.93 (0.68–12.70)	0.151
Intraoral approach	Delayed treatment	3.01 (0.78–11.60)	0.110
Malocclusion	Delayed treatment	0.37 (0.04–3.66)	0.391
OR: Odds ratio; CI: Confidence interval.			
Reference categories: Mandible for fracture site, Extraoral for surgical approach, and			
Early treatment for timing-based analyses.			
NS: Not significant ($P > 0.05$).; *Statistically significant at $P \leq 0.05$.			

Among patients with mandibular fractures, however, delayed treatment was associated with a significantly increased risk of postoperative complications, with 6.15-fold higher odds of complications compared with early treatment (OR 6.15, 95% CI 1.60–23.60; $P = 0.008$). No significant associations were observed for delayed treatment within the maxillary fracture or surgical approach subgroups (Table 8).

4. Discussion

The optimal timing of surgical management for maxillofacial fractures remains controversial despite significant advances in trauma care, fixation techniques, and perioperative management. While early intervention has traditionally been advocated to minimize complications and facilitate anatomical reduction, delayed treatment is frequently unavoidable because of patient-, injury-, and healthcare system-related factors[8, 9]. The present study evaluated the influence of treatment timing on postoperative outcomes in a cohort of 216 patients with maxillofacial fractures and demonstrated that delayed intervention was associated with significantly higher rates of postoperative infection, overall postoperative complications. Furthermore, delayed treatment emerged as an independent predictor of postoperative complications among patients with mandibular fractures. However, treatment timing was not significantly associated with malocclusion, hospital stay, or the requirement for secondary surgical intervention.

The demographic characteristics of the present cohort are consistent with the established epidemiology of maxillofacial trauma. The median age was 27 years, with the majority of patients belonging to the third decade of life, and males accounted for 84.7% of the study population. Similar findings have been reported by Hurrell et al. [10], James et al. [6], and Hassan et al.[4], who observed a predominance of young adult males among patients sustaining facial fractures. This demographic distribution reflects increased participation of young males in high-risk occupational activities, vehicular travel, and outdoor pursuits. Road traffic accidents accounted for 88.4% of injuries in the present study and represented the principal mechanism of trauma. This finding contrasts with many reports from developed countries, where interpersonal violence and assault predominate, but is consistent with patterns reported from several low- and middle-income countries where traffic-related injuries remain a major public health concern[11–13].

Mandibular fractures represented the most commonly involved anatomical region, whereas zygomaticomaxillary complex (ZMC) fractures constituted the most frequent individual fracture pattern. The predominance of mandibular involvement has been consistently reported in the literature and reflects the exposed position and biomechanical vulnerability of the mandible during facial trauma[14, 15]. Wibowo et al.[16], in their systematic review and meta-analysis, similarly identified mandibular fractures as the most frequently encountered maxillofacial injury. The high prevalence of multiple fracture sites in the present study further highlights the substantial injury burden and complexity of the trauma population evaluated.

A notable finding of this study was the prolonged interval between injury and definitive surgical management. The median treatment delay was 12 days, and nearly 89% of patients underwent delayed intervention. Late presentation was the predominant cause of delay, followed by limitations in operating theatre availability and the need for stabilization of associated injuries. These findings emphasize the challenges encountered in resource-constrained healthcare systems, where geographical barriers, referral pathways, socioeconomic factors, and limited surgical resources may significantly influence definitive care. James et al.[6] similarly identified delayed presentation, operating room constraints, and concomitant injuries as important contributors to postponement of mandibular fracture repair.

The principal finding of the present study was the significant association between delayed intervention and postoperative infection. Infection occurred in 24.5% of patients undergoing delayed treatment compared with only 4.2% of those treated early. This observation supports the concept that prolonged intervals between injury and fixation may increase bacterial colonization, promote contamination of fracture sites, and permit progressive soft tissue inflammation. Delayed treatment may also complicate surgical reduction due to fibrosis, tissue contracture, and persistent edema, thereby increasing operative complexity and the potential for postoperative wound complications[4, 17, 18].

The current findings are supported by Hassan et al. [4], who reported that mandibular fracture fixation performed more than 7 days after injury was associated with significantly increased risks of malocclusion, malunion, and unplanned reoperation. Similarly, Lander et al.[5] demonstrated that

prolonged delays in mandibular fracture management were associated with increased rates of adverse healing outcomes, particularly malunion and non-union. Collectively, these findings suggest that delayed intervention may adversely influence fracture healing and postoperative recovery, especially in fractures requiring precise restoration of occlusion and anatomical alignment.

In contrast, several investigations have failed to demonstrate a significant relationship between treatment delay and postoperative outcomes. Hurrell et al.[10], in a prospective study involving mandibular fractures, found no significant association between treatment delay and infection, wound dehiscence, malocclusion, non-union, nerve injury, or return to theatre. Likewise, James et al.[6] reported no significant correlation between the timing of repair and postoperative complications despite mean treatment delays exceeding 13 days. These discrepancies may be explained by differences in study design, sample size, fracture characteristics, definitions of delay, perioperative protocols, and healthcare infrastructure. Importantly, the proportion of delayed cases in the present study was substantially greater than that reported in many previous investigations, potentially increasing the ability to detect clinically relevant effects of treatment postponement.

Recent evidence syntheses provide additional context for interpreting these findings. Wibowo et al.[16], in a systematic review and meta-analysis of delayed versus early management of maxillofacial fractures, reported no statistically significant difference in overall complication rates between treatment groups. However, the authors observed a consistent trend toward increased rates of infection, malunion, and non-union among patients undergoing delayed treatment. Similarly, Chen et al.[7], in a systematic review evaluating fixation timing in polytrauma patients, concluded that available evidence did not demonstrate a clear advantage of delayed fixation and highlighted the overall low quality and heterogeneity of existing studies. Taken together, these findings suggest that while delayed treatment may not universally worsen outcomes, certain complications, particularly infection-related events, appear more likely to occur when definitive management is postponed.

An important observation in the present study was the significantly higher incidence of overall postoperative complications among patients treated after delay. More than half of patients in the delayed group experienced postoperative complications compared with only one-quarter of patients treated early. Furthermore, delayed intervention was associated with a significantly higher frequency of complications during the first postoperative week. These findings suggest that treatment timing may have its greatest influence during the early healing period, when bacterial contamination, inflammatory responses, and soft tissue recovery are most critical. However, the absence of significant differences at the 6-week follow-up suggests that many early complications may be manageable and do not necessarily translate into long-term adverse outcomes.

Among the postoperative complications observed, nerve injury was the most common, followed by infection and trismus. Although nerve injury occurred more frequently in the delayed group, this association did not achieve statistical significance. Nerve dysfunction following facial fracture repair is multifactorial and may result from the initial trauma, fracture displacement, surgical exposure, or fixation

procedures[19, 20]. Consequently, the influence of treatment timing alone on neural recovery may be difficult to isolate.

The present study also demonstrated that delayed treatment was associated with a six-fold increase in the odds of postoperative complications among patients with mandibular fractures. This finding is clinically important because mandibular fractures are particularly susceptible to infection owing to communication with the oral cavity, bacterial contamination from dentition, and the need to restore complex occlusal relationships[21, 22]. The results support the recommendations of Hassan et al.[4], who advocated early ORIF whenever feasible to minimize postoperative morbidity. Conversely, fracture location itself, surgical approach, and interactions with treatment timing were not significantly associated with postoperative infection. These findings suggest that the timing of intervention may exert a greater influence on outcomes than the specific anatomical site or surgical access route.

Interestingly, no significant difference in hospital stay was identified between early and delayed treatment groups. This observation is consistent with the findings reported by Chen et al.[7], who found comparable hospital and intensive care unit lengths of stay among patients undergoing early and delayed fixation. Hospital stay is influenced by numerous factors beyond fracture management, including associated injuries, medical comorbidities, social circumstances, and institutional discharge practices[23, 24]. Consequently, the isolated effect of fracture treatment timing on hospitalization duration may be difficult to demonstrate.

The present study possesses several strengths. It represents one of the larger contemporary analyses evaluating the effect of treatment timing across a broad spectrum of maxillofacial fractures. Detailed assessment of postoperative complications, follow-up outcomes, and logistic regression analyses allowed identification of clinically relevant associations between delayed treatment and adverse outcomes. Nevertheless, several limitations should be acknowledged. The retrospective design introduces the potential for selection and information bias. The markedly unequal distribution between early and delayed treatment groups may have influenced statistical comparisons. Reasons for treatment delay were multifactorial and could not be fully controlled. In addition, some subgroup analyses produced unstable estimates because of small sample sizes, resulting in wide confidence intervals and limited statistical power. Finally, long-term functional and patient-reported outcomes were not available for analysis.

In conclusion, delayed surgical management of maxillofacial fractures was associated with significantly increased rates of postoperative infection, overall postoperative complications, and early follow-up complications. Delayed intervention was also an independent predictor of postoperative complications among patients with mandibular fractures. However, treatment timing did not significantly affect malocclusion, hospital stay, or the need for secondary surgery. These findings support timely definitive management of maxillofacial fractures whenever clinically feasible while recognizing that patient factors, associated injuries, and healthcare resource limitations may occasionally necessitate treatment delay. Prospective multicentric studies with standardized definitions of treatment timing and outcome

measures are required to further clarify the relationship between surgical delay and postoperative outcomes.

Declarations

Conflict of interest:

- None

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics Approval

This retrospective cohort study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments. Ethical approval was obtained from the Institutional Ethics Committee-2025/IEC/1697

Consent to Participate

Informed consent was waived by the Institutional Ethics Committee due to the retrospective nature of the study and the use of anonymized patient data.

Consent to Publish

The manuscript does not contain any individual person's identifiable data, images, or videos. Therefore, consent for publication was not required.

Clinical Trial Number

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Author Contribution

RD was involved in Conceptualization, Methodology, and manuscript review and editing. RM and SR wrote the original Draft and helped with data curation and formal analysis. DD helped in Data Curation and Validation. SC and NH were involved in supervision, resources and validation.

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- None

Data Availability

All data underlying the results are available as part of this article. For more clarification about the findings of this study, the data can be made available on reasonable request from the corresponding author.

References

1. Jiang C, Jiang Y, Zhang X, Wen Y, Lin L, Huang L (2025) Clinical epidemiology, patterns and treatment of maxillofacial fractures in children and adolescents: a 15-year retrospective study. *BMC Oral Health* 26(1):43. <https://doi.org/10.1186/s12903-025-07283-6>
2. Khandeparker PVS, Fernandes TB, Dhupar V, Akkara F, Shetye OA, Khandeparker RVS (2024) A retrospective epidemiological review of maxillofacial injuries in a tertiary care centre in Goa, India. *Chin J Traumatol* 27(5):263–271. <https://doi.org/10.1016/j.cjtee.2022.12.004>
3. Van der Cruyssen F, Forrest M, Holmes S, Bhatti N (2025) A systematic review and meta-analysis of fracture-related infections in maxillofacial trauma: incidence, risk factors, and management strategies. *J Clin Med* 14(4):1332. <https://doi.org/10.3390/jcm14041332>
4. Hassan BA, Resnick E, Er S et al (2025) Impact of surgical timing on postoperative complications following open reduction internal fixation of mandibular fractures. *J Craniofac Surg* 36(1):211–214. <https://doi.org/10.1097/SCS.00000000000010720>
5. Lander DP, Lee JJ, Kallogjeri D et al (2021) The impact of treatment delay on malunion and nonunion after open reduction of mandible fractures. *Facial Plast Surg Aesthet Med* 23(6):460–466. <https://doi.org/10.1089/fpsam.2020.0607>
6. James J, Farrell T 4th, Stevens M, Looney S, Faigen A, Anderson J (2020) Time to open repair of mandibular fractures and associated complications. *J Oral Maxillofac Surg* 78(1):101–107. <https://doi.org/10.1016/j.joms.2019.09.009>
7. Chen J, Vuong K, Balogh ZJ (2026) Early versus delayed fixation of maxillofacial fractures in polytrauma: a systematic review. *Eur J Trauma Emerg Surg* 52(1):58. <https://doi.org/10.1007/s00068-026-03127-2>

8. Duane TM, Sercy E, Banton KL, Blackwood B, Hamilton D, Hentzen A et al (2022) Factors associated with delays in medical and surgical open facial fracture management. *Trauma Surg Acute Care Open* 7:e000952. <https://doi.org/10.1136/tsaco-2022-000952>
9. Radabaugh JP, Zhang P, Wang D, Lin PL, Shelton J, Liao JY, Cunningham LL Jr, Gal TJ (2016) Barriers to repair in maxillofacial trauma. *JAMA Facial Plast Surg* 18(3):177–182
10. Hurrell MJ, David MC, Batstone MD (2018) A prospective study examining the effects of treatment timing in the management of mandible fractures. *Int J Oral Maxillofac Surg* 47(9):1126–1131
11. Jaber MA, Al-Hmoudi A, Mathew A, Arumuganainar D, Yadalam PK, Saeed A, Abdulla S, Al Kaabi S (2025) The prevalence and pattern of oral and maxillofacial injuries in Al Fujairah population, UAE: a retrospective study. *Open Dent J* 19(1)
12. Pabbati S, Sharma D, Thomson P (2025) The epidemiology of oro-facial injuries in rural and metropolitan Queensland, Australia. *Rural Remote Health* 25(3):1–5
13. Gurung US, Singh G, Mishra M, Mondal S, Gaur A (2019) Maxillofacial injuries related to road traffic accidents: a five year multi center analysis. *Craniomaxillofac Trauma Reconstr Open* 3(1)
14. Kreh CC, Ragsdale LB, Stefanski AL, Chen K (2026) A 10-year retrospective analysis of mandibular fracture patterns in blunt and penetrating trauma. *J Craniofac Surg*. <https://doi.org/10.1097/SCS.00000000000012889>
15. Rashid S, Gupta VA, Choudhary S, Deepika D, Kumar RD (2026) Are resorbable plating systems comparable to conventional titanium plating in pediatric maxillofacial trauma patients? A systematic review and meta-analysis. *Br J Oral Maxillofac Surg*
16. Wibowo JG, Guritno T, Halim EN (2026) Early versus delayed management of maxillofacial fractures: a systematic review and meta-analysis with context-based subgroup analysis. *Oral Maxillofac Surg* 30:87. <https://doi.org/10.1007/s10006-026-01574-0>
17. Palmela Pereira C, Santos R, Santos A et al (2022) A systematic review and meta-analysis of oral and maxillofacial trauma. *J Forensic Odontostomatol* 40(3):2–21
18. Bayu M, Syamsudin E, Sylvyana M, Putri FA (2024) Management of neglected facial fracture: a case report. *Int J Med Biomed Stud* 8(5). <https://doi.org/10.32553/ijmbs.v8i5.2877>
19. Sahadevan A, Mary P, Dominic M, Varghese G, Harikumar GR, Verma KP (2024) Epidemiology of facial nerve palsy in temporal bone fractures and its treatment outcome: a prospective longitudinal study from Central Kerala. *J Otolaryngol Rhinol Res* 5(1):203–210
20. Renzi G, Carboni A, Perugini M, Giovannetti F, Becelli R (2004) Posttraumatic trigeminal nerve impairment: a prospective analysis of recovery patterns in a series of 103 consecutive facial fractures. *J Oral Maxillofac Surg* 62(11):1341–1346. <https://doi.org/10.1016/j.joms.2004.05.212>
21. Ragsdale LB, Kreh CC, Zhang A, Keller R, Chen KC (2024) Challenging the paradigm: rates of mandibular infection following fracture. *Plast Reconstr Surg Glob Open* 12(Suppl 4):39. <https://doi.org/10.1097/01.GOX.0001015320.06848.ae>
22. Rashid S, Kumar RD, Choudhary S et al (2026) A case report on virtual surgical planning and fracture reduction in the management of complex maxillofacial trauma. *J Maxillofac Oral Surg*.

23. Alsaleh H, AlObaidi S (2026) Determinants of prolonged hospital stay following a fall among older adults in Kuwait: a prospective cohort study. *Injury*:113189

24. Anthonisen NR (2008) Social factors and hospitalization. *Can Respir J* 15(7):343–344.
<https://doi.org/10.1155/2008/481304>

Figures

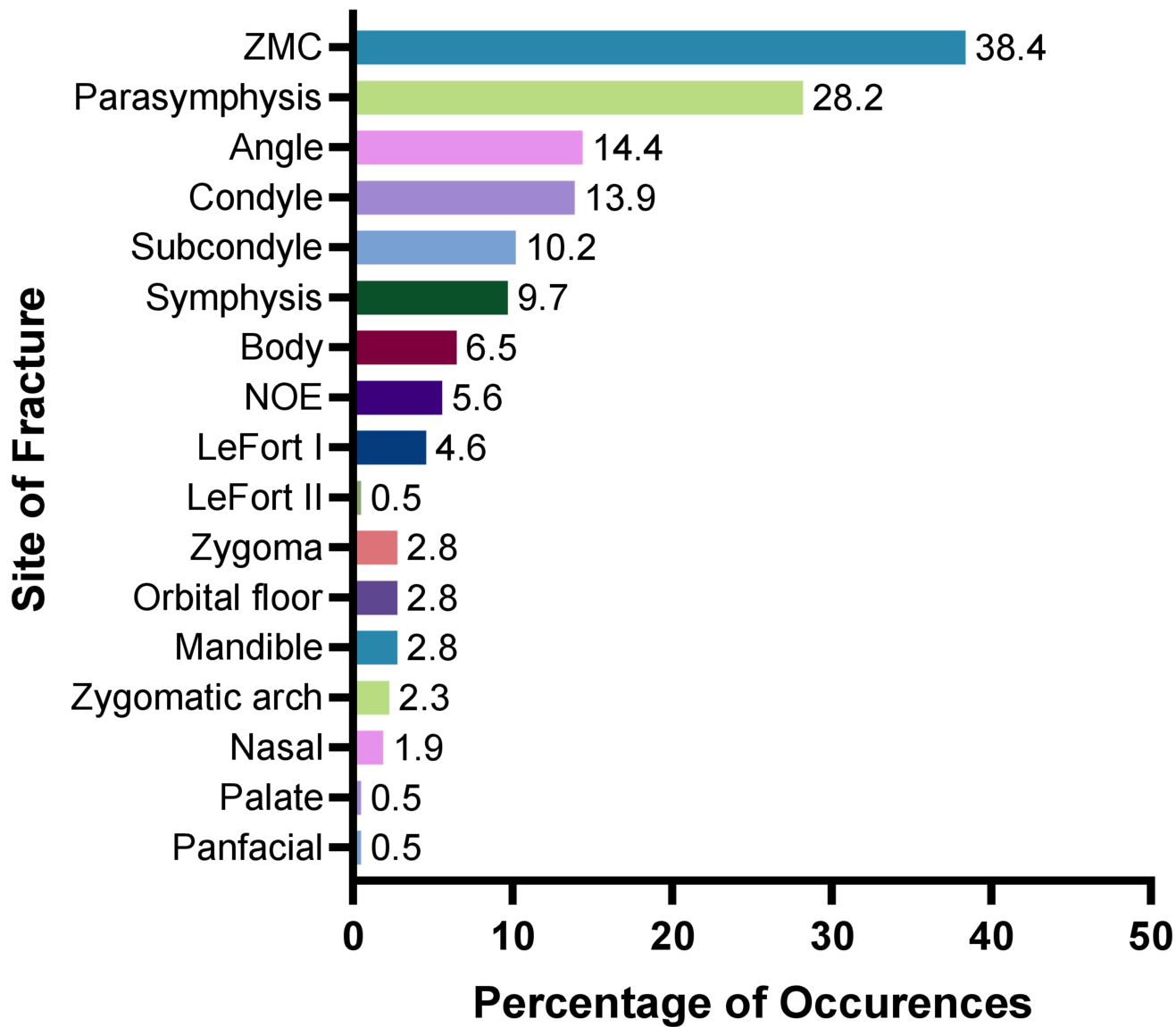


Figure 1

Distribution of maxillofacial fracture patterns in the study population

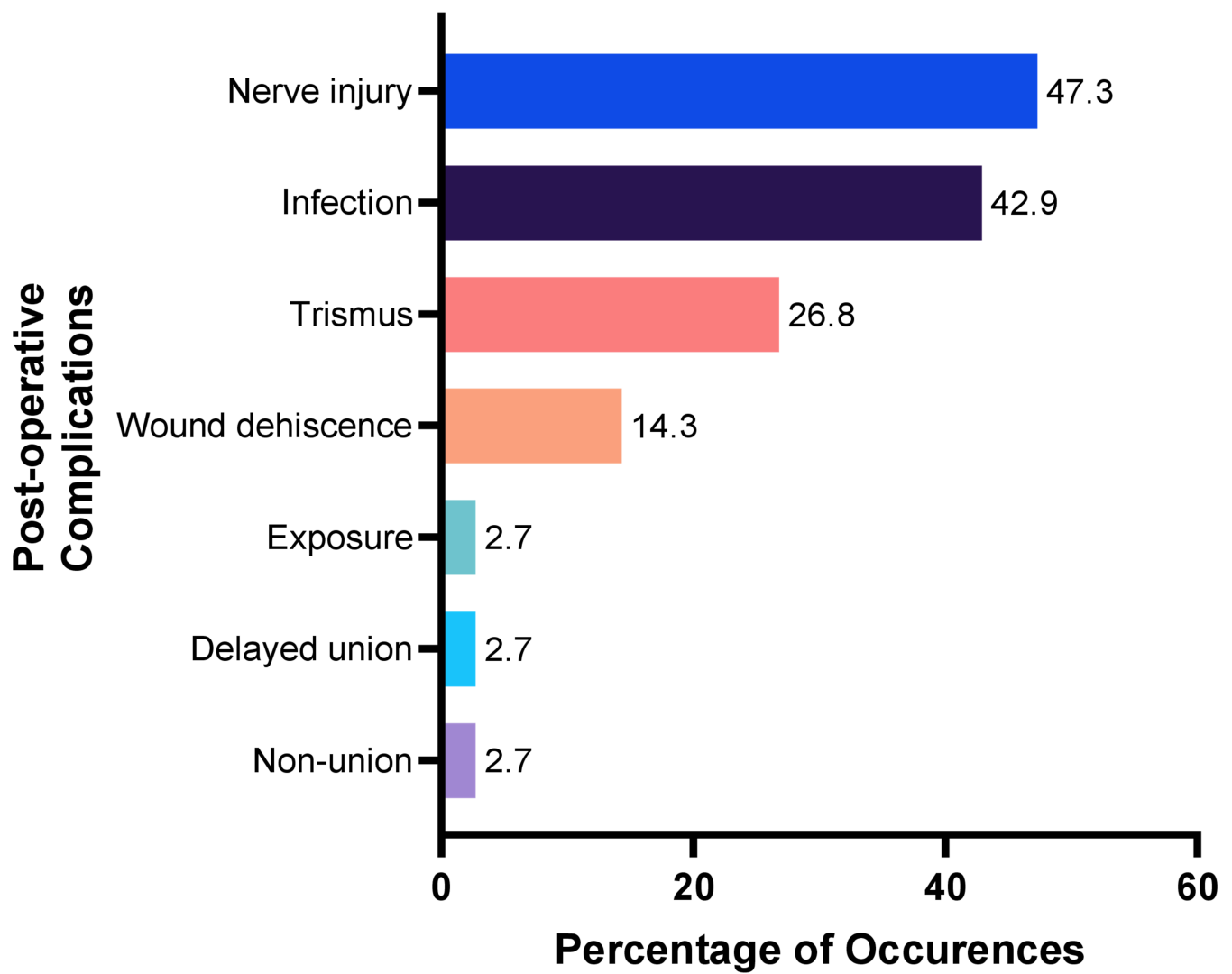


Figure 2

Distribution of postoperative complications in the study population

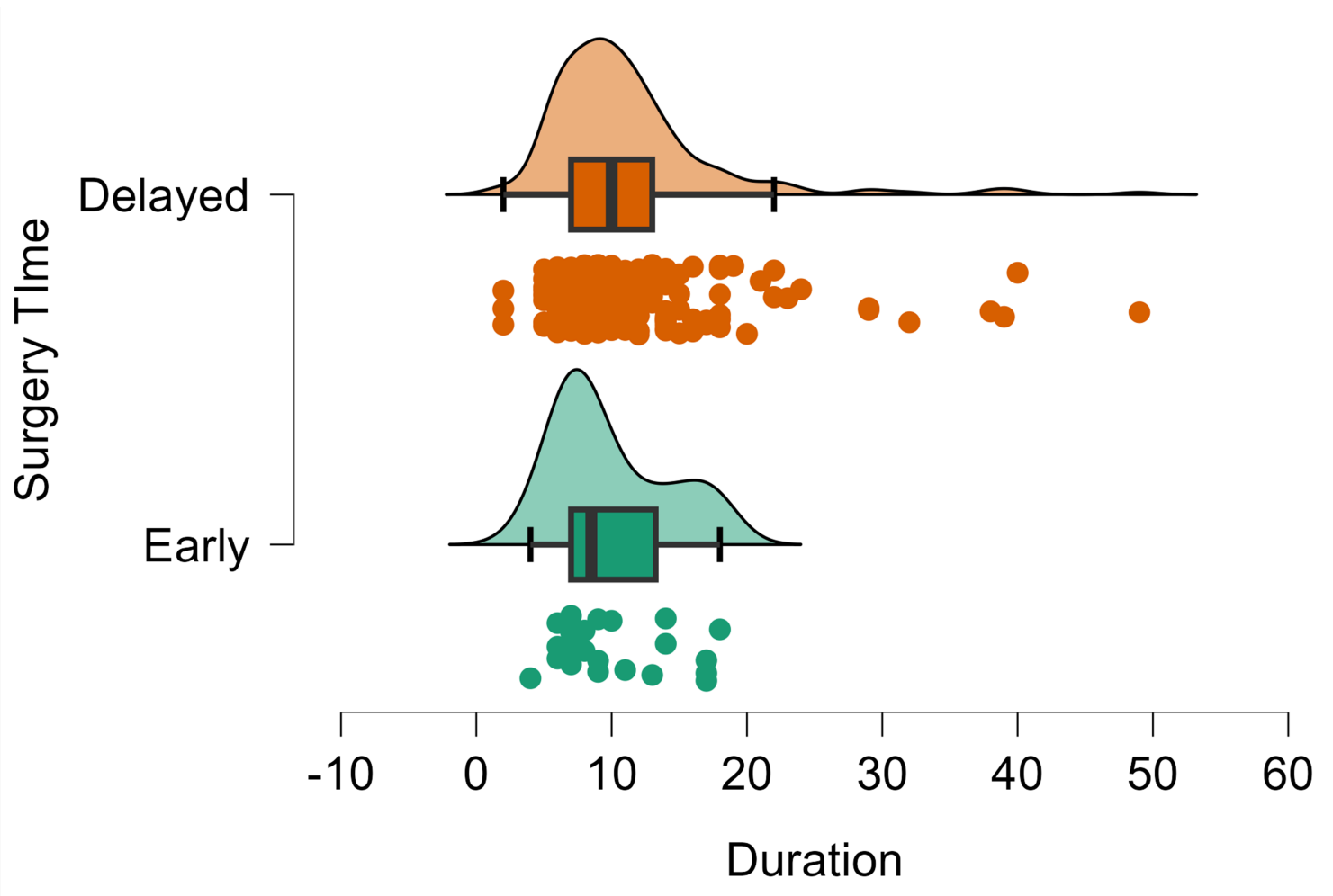


Figure 3

Raincloud plot showing the distribution of hospital stay duration according to treatment timing category.