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ORIGINAL ARTICLE

Comparison of Open Reduction and Internal Fixation Versus Closed Treatment in Firearm-Related Mandibular Fractures: A Retrospective Comparative Cohort Study

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ABSTRACT

Background: Firearm-related mandibular fractures are increasingly encountered in tertiary care settings and are associated with complex injury patterns and significant morbidity. Optimal management remains debated, particularly between open reduction and internal fixation (ORIF) and closed treatment approaches.

Methods: This retrospective comparative cohort study was conducted at Mardan Medical Complex, Khyber Pakhtunkhwa, Pakistan, from April 2024 to December 2025. A total of 202 patients with firearm-related mandibular fractures were included and categorized into ORIF (n=157) and closed treatment (n=45) groups. Outcomes included infection, non-union, malocclusion, facial asymmetry, healing time, and functional recovery. Multivariable logistic regression was performed to adjust for confounders.

Results: Non-union (15.6% vs. 4.5%, p=0.01), malocclusion (22.2% vs. 7.6%, p=0.005), and facial asymmetry (20.0% vs. 6.4%, p=0.004) were significantly higher in the closed group. Infection rates were comparable (p=0.32). ORIF demonstrated shorter healing time and improved functional recovery. Adjusted analysis confirmed higher odds of non-union (aOR 3.82), malocclusion (aOR 2.94), and facial asymmetry (aOR 2.78) with closed treatment.

Conclusion: ORIF provides superior structural and functional outcomes compared to closed treatment in firearm-related mandibular fractures and should be preferred when feasible.

Keywords: Facial Asymmetry, Firearms Injury, Mandibular Fractures, Postoperative Complications, Retrospective Studies

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Introduction

Firearm injuries are a significant public health concern (1). In these injuries, the head and neck region is most commonly affected because of its anatomical exposure. Among the facial injuries, the mandibular bone is most commonly affected because of its prominent location (2). The injury to the mandible is associated with extensive comminution, soft-tissue disruption, contamination, and a high risk of infection. These injuries may lead to severe functional impairment such as impaired occlusion, difficulty in mastication, speech limitations, airway compromise and long-term facial asymmetry and aesthetic deformity (3).

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In regions with a high prevalence of interpersonal violence and civilian firearm accessibility, the mandibular gunshot injuries form an important subset of maxillofacial trauma requiring timely and specialized management (4).

Treating mandibular fractures caused by firearm injuries is clinically challenging for surgeons as ballistic wounds are characterized by unpredictable energy transfer, irregular fracture patterns, and varying degrees of tissue destruction (5). The management options for mandibular fractures are traditional closed treatment methods such as maxillomandibular fixation (MMF), which is simple, lower cost, and avoidance of periosteal stripping (6). The second treatment modality is closed reduction, which is associated with higher rates of malunion, non-union, prolonged immobilization, difficulty in maintaining oral hygiene, and delayed return of function (7).In the third treatment approach, open reduction and internal fixation (ORIF) enables the surgeon to directly see the fracture and reduce it anatomically, which can result in rigid stabilization, making it easier to mobilize early and achieve better functional results. ORIF can potentially increase the risk of soft tissue injury, surgical site infection, or hardware exposure (3,7).

Both approaches are practiced; the current literature has inconsistent results regarding the relative effectiveness of both closed and open reductions. The previous evidence for the research is based on varied trauma mechanisms, small study populations, and outdated fixation methods, and relatively few studies have focused on firearm injuries (8). Firearm injury is a vastly different entity from blunt trauma, so the findings from blunt trauma research may not be entirely relevant (9).

There is a constant stream of firearm injuries in the tertiary care hospitals of Khyber Pakhtunkhwa, Pakistan. Due to the clinical complexity of mandibular trauma, there is a need for real-world evidence to guide treatment decisions. To fulfill this gap, this study was designed to compare the outcomes of open reduction and internal fixation with those of closed treatment in patients presenting with firearm-related mandibular fractures, with particular attention to postoperative infection, non-union, occlusal stability, and facial asymmetry. The contextually relevant data from a tertiary care hospital that regularly manages such injuries. This study will support clinical decision-making, minimize complications, and improve functional and aesthetic recovery in affected patients.

Methods

This study design was a retrospective comparative cohort analysis and was conducted in the Department of Oral and Maxillofacial Surgery at Mardan Medical Complex (MMC), Mardan, Khyber Pakhtunkhwa, Pakistan, which is a tertiary referral center that routinely manages high-energy maxillofacial trauma, including firearm injuries. Ethical approval was obtained from the Institutional Review Board of Medical Teaching Institution, Bacha Khan College of Dentistry / Bacha Khan Medical College, Mardan (Approval No: 405, dated: 12/03/2024). The study period was from April 2024 to December 2025. All the eligible cases were identified through emergency department registers, operative logs, and departmental archives. Data extraction was performed between April 2024 to December 2025, and data regarding clinical outcomes were obtained from standard six-week postoperative follow-up records.

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The inclusion criteria included patients aged 20 to 40 years who presented with a radiologically confirmed mandibular fracture caused by a firearm injury, and presented at the hospital within seven days of trauma, and had complete clinical, radiographic, and follow-up documentation. The exclusion criteria were patients with non-ballistic mandibular fractures, fractures requiring bone grafting or microvascular reconstruction, or associated non-mandibular facial fractures, any systemic medical conditions known to impair healing, or incomplete documentation were also excluded. All the eligible patients were categorized into two groups based on the definitive management they received. The ORIF group included the patients treated through open surgical exposure and rigid fixation using titanium miniplates or reconstruction plates. The closed-treatment group included patients managed non-surgically using maxillomandibular fixation (MMF) or intermaxillary fixation (IMF).

The primary outcome variables of the study were postoperative infection, non-union, malocclusion, and facial asymmetry. Postoperative infection was defined by the presence of erythema, purulent discharge, fistula formation, systemic signs of infection, or radiologic features suggestive of osteomyelitis within six weeks following the treatment. Non-union was defined as persistent mobility at the fracture site accompanied by a radiolucent gap on orthopantomogram at six weeks. Malocclusion was assessed clinically by evaluating deviation from the patient's premorbid or physiologic occlusion. Facial asymmetry was assessed visually at follow-up for any contour deformity or deviation. Secondary outcomes of the study were overall complication rates, early functional recovery, and the need for revision procedures. confounders for this study were age, sex, fracture site, degree of comminution, soft-tissue involvement, contamination, smoking status, and time interval between injury and treatment.

Data extraction was done from electronic medical records, operative reports, clinical examination forms, orthopantomograms, and computed tomography scans, which were the primary imaging modality for diagnosing and classifying fractures. The data included details regarding type of fixation hardware in the ORIF group and the MMF/IMF technique in the closed-treatment group were documented.

All eligible patients during the study period were included in the study. The initial sample size estimation was carried out during the planning of the study based on the previous infection rates published in the literature. The retrospective nature of the study allowed the inclusion of the entire population to improve the statistical power. The Shapiro-Wilk test was used to check for normality in the continuous variables. All normally distributed variables were presented as mean with standard deviation, while the skewed variables were presented as median with interquartile ranges.

The statistical analysis was carried out using SPSS version 24.0. Descriptive and inferential statistical analysis was carried out. Comparison of categorical variables between treatment groups was carried out using chi-square or Fisher exact test, while comparison of continuous variables was carried out using independent t-test or Mann-Whitney U test depending on the distribution. Multivariable logistic regression analysis was used to adjust for potential confounders such as age, sex, fracture severity, fracture location, and time to

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intervention. Adjusted odds ratio with 95% confidence interval was used.

Results

A total of 202 patients with firearm-related mandibular fractures were included, of whom 157 patients (77.7%) underwent open reduction and internal fixation (ORIF) and 45 patients (22.3%) underwent closed reduction. All patients had complete clinical and radiographic follow-up.

The mean age of the patients was 29.2 ± 5.1 years, and there was no significant difference between the ORIF and closed groups ($p > 0.05$). Males accounted for 90.1% of the study population. The type of fracture was evenly distributed, and parasymphysis, body, and angle fractures were the most frequent fracture sites. The level of comminution, smoking, and soft tissue contamination was also evenly distributed between the groups.

A detailed summary of the baseline characteristics is presented in Table 1.

Table 1. Baseline Demographic and Injury Characteristics of Patients (N = 202)

Variable	ORIF (n=157)	Closed (n=45)	Total (N=202)	p-value
Age (years), mean ± SD	29.4 ± 5.2	28.7 ± 4.9	29.2 ± 5.1	0.41
Sex				0.78
Male	142 (90.4)	40 (88.9)	182 (90.1)	
Female	15 (9.6)	5 (11.1)	20 (9.9)	
Soft-tissue contamination	78 (49.7)	21 (46.7)	99 (49.0)	0.72
Smoker	55 (35.0)	14 (31.1)	69 (34.2)	0.61
Fracture location				0.67
Parasymphysis	48 (30.6)	11 (24.4)	59 (29.2)	
Body	39 (24.8)	10 (22.2)	49 (24.3)	
Angle	35 (22.3)	12 (26.7)	47 (23.3)	
Symphysis	18 (11.5)	5 (11.1)	23 (11.4)	
Ramus	10 (6.4)	4 (8.9)	14 (6.9)	
Comminution				0.48
Mild	42 (26.8)	14 (31.1)	56 (27.7)	
Moderate	78 (49.7)	18 (40.0)	96 (47.5)	
Severe	37 (23.6)	13 (28.9)	50 (24.8)	

ORIF = Open Reduction and Internal Fixation; SD = Standard Deviation

Among ORIF patients, **73.9%** underwent fixation with miniplates and **26.1%** with reconstruction plates. In the closed group, **71.1%** were treated with arch bars and **28.9%** with eyelets. The need for debridement was more common in the ORIF group, although not statistically significant.

Treatment characteristics are presented in Table 2.

Table 2. Treatment Characteristics

Variable	ORIF (n=157)	Closed (n=45)
Type of fixation / immobilization		
Miniplates	116 (73.9%)	—
Reconstruction plates	41 (26.1%)	—
Arch bars	—	32 (71.1%)
Eyelets	—	13 (28.9%)
Mean duration of MMF (days)	—	28.4 ± 4.3
Debridement required	64 (40.8%)	13 (28.9%)

MMF = Maxillomandibular Fixation.

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Postoperative infection occurred in **11.5**% of ORIF patients and **6.7**% of closed-treatment patients, with **no statistically significant difference** (p = 0.32).Non-union was significantly higher in the closed group (**15.6**%) than in the ORIF group (**4.5**%) (p = 0.01).Malocclusion occurred in **22.2**% of closed-treatment patients compared with **7.6**% in the ORIF group (p = 0.005).Facial asymmetry was significantly more common in the closed group (**20.0**%) compared with ORIF (**6.4**%) (p = 0.004).

A full comparison of primary outcomes is shown in ***Table 3***.

Table 3. Comparison of Primary Outcomes Between Groups

Outcome	ORIF (n=157)	Closed (n=45)	p-value
Infection	18 (11.5%)	3 (6.7%)	0.32
Non-union	7 (4.5%)	7 (15.6%)	0.01*
Malocclusion	12 (7.6%)	10 (22.2%)	0.005*
Facial Asymmetry	10 (6.4%)	9 (20.0%)	0.004*

*Statistically significant (p < 0.05)

Healing time was significantly shorter in the ORIF group (5.4 ± 1.1 weeks) than in the closed group (6.7 ± 1.4 weeks). Return to normal mastication occurred more frequently after ORIF (81.5% vs. 62.2%). Revision surgery was required in 2.5% of ORIF cases versus 11.1% of closed cases. After adjusting for age, sex, fracture location, comminution severity, soft-tissue contamination, smoking status, and time to treatment, treatment modality remained an independent predictor of several outcomes.

After adjustment for age, sex, fracture location, comminution severity, soft-tissue contamination, smoking status, and time to treatment, closed treatment remained independently associated with significantly higher odds of non-union (adjusted OR (aOR) = 3.82, 95% CI: 1.45–10.11; p = 0.006), malocclusion (aOR = 2.94, 95% CI: 1.26–6.84; p = 0.01), and facial asymmetry (aOR = 2.78, 95% CI: 1.14–6.80; p = 0.02). In contrast, treatment modality was not significantly associated with postoperative infection (aOR = 0.64, 95% CI: 0.17–2.26; p = 0.48). Multivariable logistic regression results are presented in Table 4

Table 4. Multivariable Logistic Regression for Predictors of Outcomes

Outcome	Predictor (Closed vs ORIF)	Adjusted OR (aOR)	95% CI	p-value
Non-union	Treatment group	3.82	1.45–10.11	0.006*
Malocclusion	Treatment group	2.94	1.26–6.84	0.01*
Facial Asymmetry	Treatment group	2.78	1.14–6.80	0.02*
Infection	Treatment group	0.64	0.17–2.26	0.48

*Statistically significant (p < 0.05).

Discussion

This retrospective comparative cohort study demonstrated that ORIF provided superior clinical outcomes compared with closed treatment in patients with firearm-related mandibular fractures. Patients treated with ORIF had significantly lower rates of non-union, malocclusion, and facial asymmetry, together with faster healing, earlier return to normal mastication, and fewer revision surgeries. Postoperative infection rates were similar between the two groups, and multivariable analysis confirmed closed treatment as an independent predictor of poor functional and anatomical outcomes. These findings support ORIF as the preferred treatment for appropriately selected patients with ballistic mandibular fractures.

Firearm-related mandibular fractures differ from blunt trauma because ballistic injuries

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produce extensive comminution, bone loss, soft-tissue devitalization, and wound contamination, making fracture stabilization more challenging. Contemporary literature emphasizes that management should be individualized according to injury severity, combining thorough debridement, infection control, and stable fixation. Recent studies and the FLOSS severity scoring system similarly advocate treatment based on the extent of tissue injury rather than fracture location alone (10,11,12).

Despite greater surgical exposure, ORIF was not associated with a significantly higher postoperative infection rate. This finding suggests that meticulous debridement, appropriate antibiotics, careful soft-tissue management, and rigid fixation can effectively minimize infection risk. These results are consistent with recent systematic reviews and meta-analyses reporting comparable infection rates between ORIF and closed treatment when modern surgical principles are followed (13,14,15). The slightly higher numerical infection rate in the ORIF group likely reflects greater injury severity rather than the fixation method itself.

ORIF significantly reduced non-union compared with closed treatment. Stable anatomical reduction provided by rigid internal fixation promotes fracture healing by restoring mandibular continuity and minimizing inter fragmentary movement, particularly in comminuted ballistic injuries. Similar findings have been reported in recent systematic reviews and meta-analyses, which consistently identify ORIF as the most reliable approach for achieving fracture union in firearm-related mandibular trauma (6,13,17).

Patients managed with ORIF also experienced significantly lower rates of malocclusion and facial asymmetry. Direct visualization of fracture fragments allows accurate restoration of occlusion and mandibular contour, resulting in improved function and aesthetics. These findings agree with previous randomized trials and systematic reviews demonstrating superior occlusal stability, mandibular function, and facial symmetry following ORIF compared with conservative treatment (7,15,18,19). Although some of these studies evaluated condylar fractures, the biomechanical advantages of stable fixation are equally relevant to ballistic mandibular injuries.

The present study has several limitations. Its retrospective single-center design introduces the possibility of selection bias, and treatment allocation was influenced by fracture severity and surgeon preference. Detailed information regarding firearm characteristics, degree of comminution, and long-term patient-reported outcomes was not consistently available. Nevertheless, the relatively large cohort and adjustment for important confounding variables strengthen the validity of the findings.

In conclusion, ORIF provided superior functional and anatomical outcomes without increasing postoperative infection in patients with firearm-related mandibular fractures. These findings support ORIF as the preferred management strategy for displaced or comminuted ballistic mandibular injuries when soft-tissue conditions permit. Prospective multicenter studies with standardized injury severity classification and longer follow-up are warranted to further refine treatment recommendations.

Limitations

Our study has certain limitations such as being a retrospective study, which has a natural selection bias, and being a single-center study, which makes it less generalizable. Further prospective and

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multicenter studies are required to improve the management algorithms in mandibular trauma.

Future Recommendations

Future prospective multicenter studies with larger sample sizes are needed to validate the findings of the present study and improve their generalizability. Further research should evaluate long-term functional outcomes, patient-reported quality of life, masticatory efficiency, and aesthetic satisfaction following open reduction and internal fixation (ORIF) and closed treatment of firearm-related mandibular fractures.

Conclusion

Our study shows that open reduction and internal fixation (ORIF) has better structural and functional results than closed management in firearm-related mandibular fractures. Our results underscore the limitations of closed management in the treatment of high-energy ballistic injuries, in which comminution, displacement, and soft tissue injury often result in instability and poor reduction. Based on our results, ORIF can be considered the treatment of choice in firearm-induced mandibular fractures.

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References

1. Fontanarosa PB, Bibbins-Domingo K. The unrelenting epidemic of firearm violence. Jama. 2022;328(12):1201–3.
2. Li Y, Fan H, Gao XL. Ballistic helmets: Recent advances in materials, protection mechanisms, performance, and head injury mitigation. Compos Part B Eng. 2022;238:109890.
3. Hesham A, Geiger J, Alshamrani Y, Sawatari Y. Can the mechanism of injury impact the location of a mandibular fracture? A systematic review. J Maxillofac Oral Surg. 2024;23(2):363–70.
4. Ou Z, Ren Y, Duan D, Tang S, Zhu S, Feng K, et al. Global burden and trends of firearm violence in 204 countries/territories from 1990 to 2019. Front Public Health. 2022;10:966507.
5. Powers DB, Holmes J. Maxillofacial Firearm Injuries. In: Peterson's Principles of Oral and Maxillofacial Surgery. Springer; 2022. p. 785–812.
6. Pepper T, Powers D. Open Versus Closed Management for Gunshot Wounds of the Mandible–Which More Frequently Achieves Satisfactory Bony Union? A Systematic Review and Meta-Analysis. J Oral Maxillofac Surg. 2025;83(7):852–62.
7. Rikhotso RE, Reyneke JP, Nel M. Does open reduction and internal fixation Yield better outcomes over closed reduction of mandibular condylar fractures? J Oral Maxillofac Surg. 2022;80(10):1641–54.
8. Aboelnaga AM, Elsahfy MF, Adly OA, Gomaa AA. Comparative Study between Open and Closed Reduction in Management of Subcondylar and Ramus Mandibular Fractures. Suez Canal Univ Med J. 2023;26(2):35–45.
9. Stefanopoulos PK, Breglia GA, Bissias C, Nikita AS, Papageorgiou C, Tsiatis NE, et al. Firearm Injuries: A Review of Wound Ballistics and Related Emergency Management Considerations. Emerg Care Med. 2025;2(4):52.
10. Daniels JS, Albakry I, Braimah RO, Samara MI, Albalasi RA, Al-Rayshan SMA. Management of Maxillofacial Gunshot Injuries With Emphasis on Damage Control Surgery During the Yemen Civil War. Review of 173 Victims From a Level 1 Trauma Hospital in Najran, Kingdom of Saudi Arabia. Craniomaxillofacial Trauma

DOI: https://doi.org/10.59736/IJP.24.02.1085

Reconstr. 2022 Mar;15(1):58–65. doi:10.1177/19433875211012211
11. Brauner E, Laudoni F, Amelina G, Cantore M, Armida M, Bellizzi A, et al. Dental Management of Maxillofacial Ballistic Trauma. J Pers Med. 2022 Jun 5;12(6):934. doi:10.3390/jpm12060934
12. Bourn L, Slovacek C, Lu N, Pocha CC, Wilbert H, Chen C, et al. Managing Low-Velocity Mandibular Gunshot Wounds: An Institutional Review and the "FLOSS" Severity Scoring System. J Craniofac Surg. 2025 Mar;36(2):518–22. doi:10.1097/SCS.0000000000010963
13. Da Rocha SS, Sales PHDH, Carvalho PHR, Maia RN, Gondim RF, De Menezes Junior JMS, et al. Mandibular traumas by gunshot. A systematic review with meta-analysis and algorithm of treatment. Br J Oral Maxillofac Surg. 2021 Apr;59(3):e99–108. doi:10.1016/j.bjoms.2020.08.019
14. Pepper T, Powers D. Open Versus Closed Management for Gunshot Wounds of the Mandible – Which More Frequently Achieves Satisfactory Bony Union? A Systematic Review and Meta-Analysis. J Oral Maxillofac Surg. 2025 Jul;83(7):852–62. doi:10.1016/j.joms.2025.04.003
15. Shobha ES, Nainoor N, Prashanth NT, Rangan V, Malick R, Shetty S. Comparative Evaluation of Open Reduction with Internal Fixation Against Closed Reduction Methods for Condylar Fracture Management: A Systematic Review and Meta- analysis. J Maxillofac Oral Surg. 2024 Jun;23(3):475–87. doi:10.1007/s12663-024-02125-4
16. Agier P, Tyszkiewicz S, Kozakiewicz M. Effectiveness of Open Rigid Internal Fixation of Condylar Fracture Resulting in Temporomandibular Joint Function Recovery. Dent J. 2025 Dec 1;13(12):562. doi:10.3390/dj13120562
17. Rashid S, Kumar RD, Kalimuddin KS. Closed treatment versus open reduction and internal fixation for mandibular condylar head fractures: A systematic review and meta-analysis. J Cranio-Maxillofac Surg. 2026 Jul;54(7):104560. doi:10.1016/j.jcms.2026.104560
18. Jazayeri HE, Lopez J, Khavanin N, Xun H, Lee UK, Best DL, et al. Comparative Benefits of Open versus Closed Reduction of Condylar Fractures: A Systematic Review and Meta-Analysis. Plast Reconstr Surg. 2023 Apr;151(4):664e–72e. doi:10.1097/PRS.0000000000010009
19. Comparison of Outcomes Between Open and Closed Reduction for Mandibular Condylar Fractures. J Coll Physicians Surg Pak. 2026 Jan 1;17–21. doi:10.29271/jcpsppg.2026.01.17

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Manuscript writing and approval	KZ,SK,SU,AA,SMH,AR
All the authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed.	

KEY FOR CONTRIBUTION OF AUTHORS:

A. Conception/Study/Designing/Planning
B. Active Participation in Active Methodology
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