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Original article

Management of Mandibular Angle Fracture: Comparative Outcomes of Surgical vs. Conservative Approaches in Libya

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Abstract
This study compares outcomes between surgical (open reduction and internal fixation [ORIF]) and conservative (intermaxillary fixation [IMF]) management approaches for mandibular angle fractures. A five-year multicenter retrospective analysis (2015-2019) was conducted on 64 patients treated across various hospitals in Western Libya. Patient demographics, fracture etiology, treatment modalities, healing duration, and complications were systematically evaluated. The results revealed that assaults/fights (56.3%) represented the predominant etiology, with males aged 20-29 years most frequently affected (71.9% male *p*=0.02 vs. females). Conservative treatment with IMF demonstrated superior healing rates, with 96.8% of cases achieving union within 9 weeks versus 57.58% for surgical interventions ORIF (*p*<0.001, x2 test). The overall complication rate was 10.9% (abscess formation and delayed union), with no statistically significant difference between the IMF (9.7%) and ORIF (12.1%) groups (p*=0.74). These findings suggest that fracture line characteristics (favorable versus unfavorable) should be the primary predictor of treatment success (*OR*=4.2, 95%CI: 1.8-9.3). IMF is optimal for stable, non-displaced fractures, while ORIF remains indicated for displaced /unstable patterns. The study provides evidence-based guidance for clinical decision-making in mandibular angle fracture management. Limitations include retrospective design and single-region data.
Keyword. Mandibular Angle Fracture, Intermaxillary Fixation, Open Reduction and Internal Fixation.

Introduction

The mandible, or lower jaw, is a complex structure that plays a crucial role in facial aesthetics, mastication, and speech. Its anatomy significantly influences the occurrence and management of fractures, particularly at the mandibular angle [1]. The mandibular angle, defined by its thin cross-section and association with the third molars, is highly susceptible to fractures due to biomechanical stress during trauma [2,3]. The angle of the mandible is the region where the body of the mandible meets the ramus, a structural weakness that increases fracture risk under trauma [4]. The presence of third molars (wisdom teeth) exacerbates this vulnerability by acting as stress concentrators [5,6]. These fractures are classified as favorable or unfavorable based on fracture line orientation and displacing forces from masticatory muscles (masseter, temporalis, medial pterygoid), which either stabilize or distract fracture fragments [5,7]. Muscular forces can further concentrate stress at the angle during impacts, predisposing this area to fractures [8]. The anatomical features of the mandibular angle influence treatment strategies; for example, surgical approaches depend on fracture location and surrounding structures [9]. Nondisplaced fractures may be treated conservatively, while complex fractures often require open reduction and internal fixation (ORIF) using plates and screws [10]. Mandibular angle fractures are associated with high postoperative complication rates, including malocclusion and infection [11]. Accurate imaging (e.g., panoramic radiography, CT scans) is critical for diagnosis and planning, as it reveals fracture extent and relationships to adjacent structures [12]. The anatomy of the mandible, particularly at the angle, plays a pivotal role in the incidence and management of fractures. The unique structural characteristics, including the thinner bone and the presence of third molars, contribute to the vulnerability of this area. Understanding these anatomical factors is essential for effective diagnosis, treatment planning, and minimizing complications associated with mandibular angle fractures.

One of the critical decisions in the treatment of mandibular angle fractures is choosing between surgical intervention and conservative management. Each approach has advantages and disadvantages, with the choice depending on factors such as fracture displacement, biomechanical stability, and patient comorbidities [11,13]. Surgical management via open reduction and internal fixation (ORIF) provides rigid stabilization through plates and screws, enabling precise anatomical alignment and early functional recovery [14,9]. However, ORIF carries risks such as infection (6–12% incidence) and iatrogenic nerve injury, particularly with extraoral approaches [15]. The biomechanical principles underlying ORIF, such as neutralizing tension zones along the mandibular superior border, originate from Champy's work emphasizing monocortical miniplate fixation to counteract masticatory forces [16]. While ORIF is optimal for displaced or comminuted fractures, its cost and invasiveness remain drawbacks in resource-limited settings [17]. Conservative management with intermaxillary fixation (IMF) avoids surgical risks and is cost-effective for non-displaced fractures [18]. However, prolonged immobilization (typically 6–9 weeks) can lead

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to temporomandibular joint stiffness, malnutrition, and patient non-compliance [19]. Recent studies suggest IMF success hinges on strict patient selection, favoring fractures with favorable biomechanical orientation (e.g., non-comminuted, minimal displacement) [20]. For example, Ribeiro-Junior et al. (2018) demonstrated that IMF achieves union rates >90% in stable fractures but fails in cases with poor dentition or segmental mobility [20]. The decision-making process must account for fracture complexity, patient compliance, and socioeconomic factors. For instance, minimally invasive techniques (e.g., transbuccal trocar-assisted plating) now allow ORIF with reduced soft tissue dissection, lowering infection risks while maintaining stability [21]. Conversely, hybrid approaches combining the IMF with limited ORIF are gaining traction for moderately displaced fractures, balancing invasiveness and functional outcomes [22].

In cases where the fracture is severely displaced or involves multiple fractures, surgical intervention may be the preferred approach to achieve optimal outcomes [23]. Conversely, conservative management may be suitable for minimally displaced fractures or in patients with contraindications to surgery [24]. Ultimately, the decision should be made in consultation with a multidisciplinary team, including oral and maxillofacial surgeons, to ensure the best possible treatment plan tailored to the individual patient's needs [25]. The choice between surgical and conservative management hinges on a multitude of factors, each with its own set of advantages and considerations [26]. Surgical intervention typically involves open reduction and internal fixation (ORIF), aimed at achieving precise anatomical alignment of the fractured fragments using plates, screws, or wires [27]. In contrast, conservative management entails immobilization of the jaw through intermaxillary fixation (IMF), restricting movement to facilitate natural healing of the fracture without surgical intervention [28]. This study provides a comprehensive comparative analysis of surgical (ORIF) and conservative (IMF) management strategies for mandibular angle fractures to establish evidence-based treatment algorithms tailored to everyday clinical practice. By examining variables such as fracture severity, patient demographics, functional and aesthetic outcomes, complications, recovery time, cost-effectiveness, and long-term stability [29], we aim to elucidate the nuanced decision-making process guiding treatment selection. Our analysis of 64 Libyan patients addresses critical gaps in low-resource settings [17], where delayed interventions and suboptimal fixation methods remain prevalent. While ORIF offers rigid stability and precise anatomical alignment, it carries risks such as infection and nerve injury [22]; conversely, IMF avoids surgical invasiveness but requires prolonged immobilization and patient compliance, with potential complications like malunion [19]. Guided by the principle of “maximizing clinical efficacy with minimal intervention”—balancing patient outcomes, surgeon effort, and resource constraints—this study evaluates the advantages, disadvantages, and contextual factors influencing treatment choice. We compare clinical outcomes, complication rates, and socioeconomic considerations (e.g., cost, accessibility) to determine optimal scenarios for each approach [30]. Ultimately, our findings aim to clarify which methods are most suitable for specific fracture types, patient populations, and resource availability, providing actionable recommendations for oral and maxillofacial surgeons to optimize care in diverse clinical settings.

Methods

This retrospective observational study analyzed 64 consecutive cases of traumatic mandibular angle fractures treated between January 2015 and December 2019 at tertiary care hospitals in Western Libya. Patients were managed through a multidisciplinary approach involving oral and maxillofacial surgery, emergency medicine, and collaborating regional institutions, with all cases referred to the lead author (the treating surgeon) to standardize diagnostic and therapeutic protocols. Inclusion criteria comprised patients aged ≥10 years with radiographically confirmed mandibular angle fractures (isolated or combined), diagnosed via panoramic radiographs or computed tomography (CT) scans, and traumatic etiology (road traffic accidents, assaults, or falls). Exclusion criteria comprised: pathological fractures or prior surgeries (e.g., tumors, osteoporosis), incomplete medical records, loss to follow-up, systemic contraindications to surgery (e.g., severe coagulopathy), or prior mandibular surgical interventions.

Data were systematically extracted from hospital records, capturing demographics (age, gender), etiology, and clinical variables including fracture type (open/closed), time from trauma to definitive treatment (hours/days), treatment modality (intermaxillary fixation [IMF], open reduction internal fixation [ORIF], or combined approaches), and immobilization duration (weeks). Outcomes assessed encompassed sensory disturbances (hypoesthesia, anesthesia) and complications (infection, mal-union, non-union), with this study addressing critical gaps in resource-limited settings where delayed presentation and reliance on wire fixation persist [12]. All patients received standardized care beginning with emergency airway stabilization and hemorrhage control when required. Diagnostic imaging protocols included panoramic radiographs for initial assessment and CT scans (with 1 mm axial and coronal slices) for complex fracture classification.

Surgical intervention followed a predefined algorithm: ORIF using titanium miniplates (2.0 mm system) or wire fixation for displaced fractures (>2 mm displacement), while IMF (Erich arch bars with 0.4 mm stainless steel ligation) was reserved for non-displaced fractures or as adjunctive stabilization. ORIF subgroups included wire fixation (n=10) and miniplate fixation (n=23), with adjunctive IMF used in 30 cases. Postoperative regimens included antibiotic prophylaxis (amoxicillin/clavulanate 625 mg three times daily for 5 days), analgesics (paracetamol and NSAIDs), and scheduled follow-up evaluations at 1, 3, 6, and 12 months to monitor healing progression and complications. Statistical analysis was conducted using SPSS

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v26 (IBM Corp.). Descriptive statistics (frequencies, percentages) summarized demographic and etiological distributions. Categorical variables, such as fracture type versus etiology, were compared using chi-square or Fisher's exact tests, while non-parametric temporal data (time to treatment) were analyzed with the Kruskal-Wallis test. Pre- and postoperative sensory changes were evaluated via McNemar's test for paired nominal data, with a threshold of *p*<0.05 defining statistical significance.

Results

The study included 64 patients with traumatic mandibular angle fractures, predominantly males (71.9%) aged 20-29 years. The cohort's age distribution is summarized in Table 1. Assault (56.3%) was the leading etiology, followed by traffic accidents (29.7%) were screened into this total, 46 were male and 18 were female (28.1 %), with a male-to-female ratio of 2.6:1. (Table 1).

Table 1. Patient Demographics and Clinical Characteristics n=64

Variable	Total (n=64)
Age (mean ± SD)	24.5 ± 5.8
Male, n (%)	46\64 (71.9%)
Female n (%)	18\64 (28.1%)
Etiology, n (%)	
Assaults	36\64 (56.3%)
RTAs	19\64 (29.6%)
Falls	9\64 (14.1%)
Fracture Type, n (%)	
Open	33\64 =51.6%
Closed	31\64 =48.4%
Time to treatment (Days)	5 (3-8)
Tooth In Fracture Line n (%)	25\64 (39.1%)

Mandibular angle fractures were found to occur in the age range from 10-19 with the highest incidence at 20-29 years, median age of 24.5 years, no patients were aged below 10 years, and 2 patients were above 50 years of age. As the etiology is concerned (Figure 1). the mandibular angle fractures are caused by many etiological factors such as road traffic accidents (19 cases 29.7%), and (35 cases 56.3%) patients sustained their mandibular angle fractured as a result of interpersonal conflicts and assault resulted in trauma to the mandibular bone and fractures mainly at the angle. "Assaults (56.3%) were the leading etiology (Figure 1), followed by road traffic accidents (RTAs; 29.7%)."

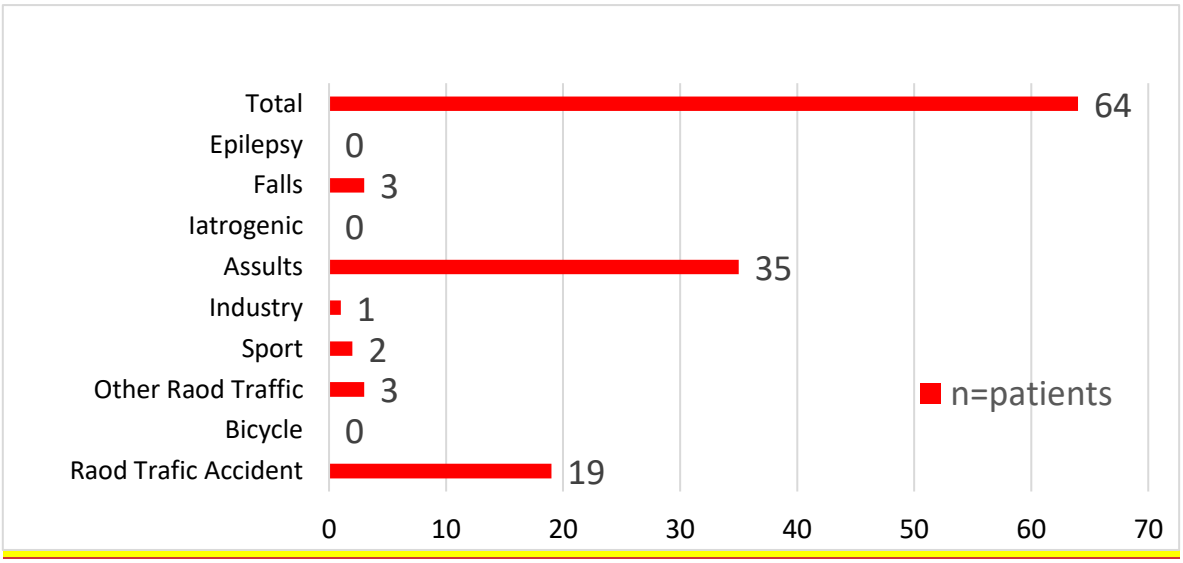

Figure 1. Distribution of Etiologies for Mandibular Angle Fractures (n=64).

There were three modalities of treatment of mandibular angle fractures; one is conservative by using intermaxillary fixation (IMF) (Winter arch bar was fixed by 0.4mm stainless steel wire and the sharp edges of the wire were bended and curved toward the arch bar and covered with self-cure acryl after careful evaluation of teeth available to make sure that the teeth will withstand the force of arch bar application and fixation, no arch bar was fixed if the number of teeth is less than 6 sound teeth in each jaw). The other two treatment modalities of treatment are surgical; both of them include open reduction with wire or miniplate fixation (Table 2).

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Table 2. Treatment Modalities

Treatment	N (%)	Details
IMF Only	31 (48.4%)	-
ORIF Only	3 (4.7%)	
ORIF + IMF	30 (46.9%)	
Total surgical cases	33 (51.6%)	Wire Fixation: 3 Cases Wire Fixation: 7 Cases Miniplates: 23 cases

Total Surgical Cases 33 (51.6%): -Wire Fixation

The healing of the bony fractures was considered perfect if there was no interfragmental movement, and the author evaluated and performed it. The opening of the mouth, perfect occlusion sensibility changes were also evaluated using clinical and radiographic procedures of evaluation. As the definitive treatment is concerned, no patient was treated before 24 hours, only 5 patients were treated within the first and second day of trauma, and 18 patients were treated in 3-4 days. Most patients, n=27 (42%), received definitive treatment in 5-10 days' post-injury, with road traffic accident victims experiencing longer delay (median: 8 days vs. 3 days for assaults, *p*=0.02) (Figure 2).

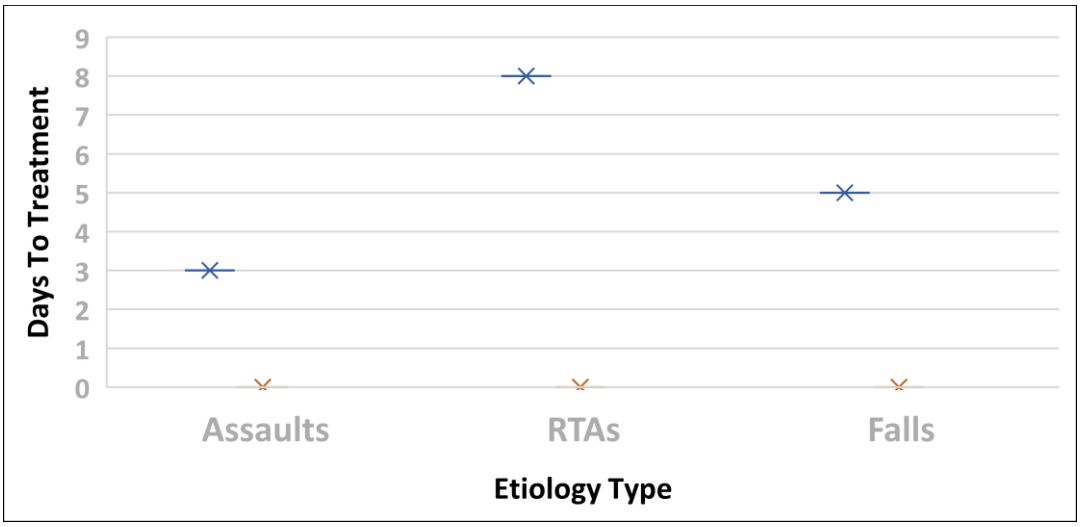

Figure 2: Significant treatment delay in RTA patients versus assault victims. Boxes represent interquartile range; horizontal line indicates median.

The patients with mandibular angle fractures due to road traffic accidents gained definitive treatment of their mandibular angle fractures later than the fractures due to other etiological groups. Intermaxillary fixation (IMF) is used as a method of treatment with the Eric arch bar. It is the fastest compared with the other two methods, including surgery. The average period of healing of the lower jaw fractures lasts for 6 weeks starting from the date of definitive treatment. IMF–treated fractures healed faster (median: 6 weeks) vs. ORIF (median: 9 weeks, p<0.001) (Figure 3).

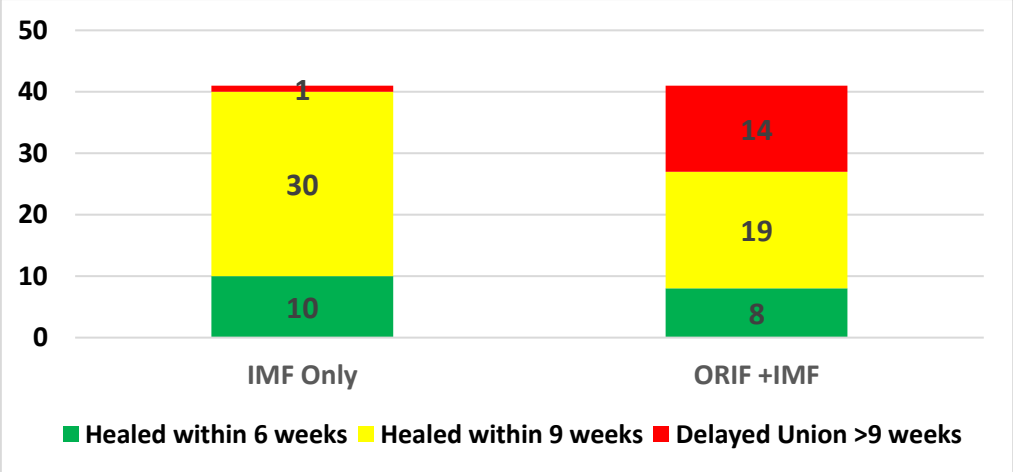

Figure 3: Comparison of healing time between treatment modalities. IMF-treated fractures healed significantly faster than ORIF-managed cases.

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It depends on age, degree of displacement, and the general health of the patient. The fractures caused by assaults and fights are in a better position concerning the bony healing than those of road traffic accidents and falls. Out of 64 patients with traumatic mandibular angle fractures (31 patients 48.4%) were treated conservatively, 3 only (4.7%) by surgery, and 30 46.8% were treated by using the combination of surgery and IMF (Figure 3 highlights faster healing with IMF (6 weeks vs. 9 weeks for ORIF).
Eric arch bars were used for IMF in 59 patients, and in 2 cases, the acrylic cap splints with circumzygomatic wiring were used as the method for intermaxillary fixation. (Conservative versus surgical ways of treatment means that the distribution of favorable and unfavorable fracture lines is equal, because the indications for surgery (only or with IMF) or conservative treatment (IMF) depend on the characteristics of the fracture line. The etiology has nothing to do with the distribution, as it can be seen in this study.
Two surgical methods have been selected and used in the treatment of mandibular angle fractures, which are wire fixation and miniplate fixation, which require IMF, but miniplates can be applied without it. The proper use of miniplates alone (without IMF) is equal to its "proper "usage (with IMF), and it is very rare. Surgical treatment was used to treat the mandibular angle fractures in 3 cases, and 30 cases were treated by open reduction and IMF, while in 31 cases, the IMF was the only treatment option used for treatment of the mandibular angle fracture. The clinical healing of mandibular angle fractures is achieved in those treated by only IMF (31 patients),10 patients (32.3%) healed completely in 3-6 weeks, 8 of 30 patients treated with surgical reduction and wire fixation (26.7%) healed in 3-6 weeks and only 1 One patient where his fracture took more than 9 weeks to get completely healing.
Following the conservative treatment, 32.3% of patients had gained their bony healing between 3 and 6 weeks, while following surgical treatment, only 24.2% of fractures were healed at the same period. In another way, 30 of 31 (96.8%) patients or fractures of those treated conservatively by only IMF had their bone healed in less than 9 weeks and 19 0f 33 patients (57.6%) of those treated their fractures by surgical methods (open reduction and wire or/and with miniplates fixation). Conservative management achieved significantly higher union rates (96.8% within 9 weeks) compared to ORIF (57.6%, *p*<0.001) (Figure 4).

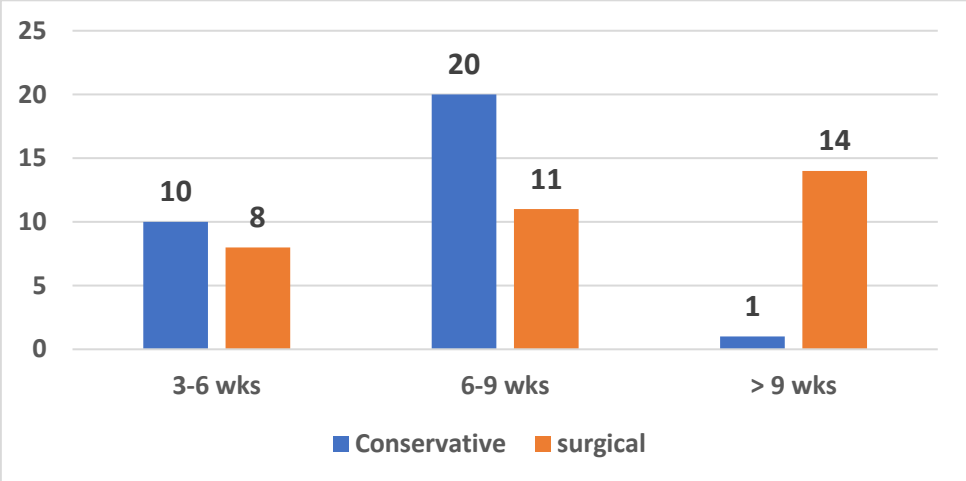

Figure 4: Union rates within 9 weeks by treatment group. Conservative management (IMF) achieved significantly higher union rates (96.8%) than ORIF (57.6%; p<0.001).

Only 1 case in which the healing of the fracture took more than 9 weeks, and that's because of the delayed union of the fracture due to infection at the site as a result of presence of tooth at fracture line which was extracted and the healing achieved in more than 9 weeks of immobilization using IMF. On the other hand, 14 out of 33 fractures that were treated by open reduction and either fixation of the fragments by wire fixation or by miniplates one plate or two plates, the 14 (42.4%) patients or fractures, their fractures took more than 9 weeks to gain clinical bony healing which in some considerations can be explained by the use of wire fixation in some fractures and the use of only one plate instead of two relaying on IMF postoperatively to ensure the fixation and immobilization. Regarding teeth at mandibular angle fracture lines, third molars were extracted in 39.1% of cases (25/64), primarily due to mobility or caries. Retained molars correlated with delayed union (*p*=0.03). The extraction was performed at the time of definitive treatment according to the general standards of indications and contraindications of tooth extraction at the fracture line. As the post-operative complications is concerned,7 cases (10.9%) developed some sort of complications post operatively 1 abscess (related to IMF), 1 chronic osteomyelitis (also related to surgical reduction, wire fixation with IMF), and 4 delayed union of which 3 cases are due to tooth retained at fracture line and the conservative method was used (IMF) and one cases a mal- union is developed in which open reduction was used and the fractured fragment was fixed using wire fixation with intermaxillary fixation. Brucoli et.al. 2019 in a European research project regarding a study of mandibular angle fractures reported that complications are less with the use of Champy miniplates techniques than with other methods of fracture fixation.

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Table 3. Complications and healing outcomes of mandibular angle fracture by treatment group

Outcome	IMF (n=31)	ORIF (n=33)	RR (95% CI)	p-value
Complications				
Infection	6.5%	9.1%	1.4 (0.3–6.2)	0.71
Delayed union	3.2%	6.1%	1.9 (0.2–18.1)	0.61
Nerve hypoesthesia	3.2%	18.2%	5.7 (1.1–28.9)	0.04
Healing Time				
Healed within 9 weeks	96.8%	57.6%	—	<0.001

*Notes: Bolded values indicate statistical significance (*p* < 0.05). RR = Risk Ratio; CI = Confidence Interval. (ORIF=open reduction internal fixation; IMF=intermaxillary fixation.*

The method of treatment, whether conservative or surgical, does not influence complications and has the same results, with no statistically significant differences between them. Following trauma to the mandibular angle, the sensory disturbances can occur in two modalities, such as anesthesia and hypoesthesia, at the region supplied by the left or right mental nerve. Sensory disturbances indicate that some kind of injury to the inferior alveolar nerve is present, due to mandibular fracture and mainly of the wall of the mandibular canal. No patient complains of anesthesia either pre- or post-operatively. 15 patients (23.4%) suffered from hypoesthesia, predominantly in surgical cases (n=12, p=0.03), of which 3 patients were treated with IMF only, 10 patients were treated with surgery and IMF, and 2 other cases were treated by only surgery (plating). Complication rates were comparable between groups (10.9% overall), though nerve hypoesthesia occurred more frequently in ORIF cases (18.2% vs. 3.2%, p=0.04).

Discussion

Our retrospective analysis of 64 mandibular angle fractures in a Libyan cohort provides important insights into the management of these complex injuries. Our findings from Western Libya contrast with global trends, where RTAs dominate over assaults (56.3% in our cohort vs. 30-50% in Global North studies. This may reflect regional sociocultural factors. The demographic profile aligns with global patterns, showing a strong male predominance (71.9%, male-to-female ratio 2.6:1) with peak incidence among young adults aged 20–29 years (median age 24.5 years) [31]. Notably, interpersonal violence (56.3%) emerged as the leading etiology, contrasting with studies from other regions where road traffic accidents predominate [2]. This epidemiological pattern underscores the need for targeted preventive strategies in our sociocultural context, particularly focusing on young male populations where high-risk behaviors are prevalent [32].

The anatomical vulnerability of the mandibular angle accounts for its significant representation among mandibular fractures, comprising approximately 32% of cases in our series [33]. Our treatment outcomes revealed striking differences between conservative and surgical approaches. Intermaxillary fixation (IMF) demonstrated superior results for stable, non-displaced fractures, achieving bony union in 96.8% of cases within 9 weeks. This success rate significantly outperformed surgical outcomes (57.58% union within the same timeframe), though this disparity primarily reflects appropriate case selection rather than inherent superiority of one technique over another [34].

The excellent results with the IMF for stable fractures reinforce its role as first-line treatment for non-displaced injuries, aligning with principles of minimally invasive trauma management [35]. The advantages of the IMF include avoidance of surgical risks such as infection or nerve injury, reduced healthcare costs, and elimination of hardware-related complications [31]. However, successful IMF requires careful patient selection, focusing on fractures with favorable biomechanical orientation and patients with adequate dentition for secure fixation (minimum six teeth per arch). Equally crucial is strict compliance monitoring through regular follow-up visits and patient education [11].

For displaced or unstable fractures, open reduction and internal fixation (ORIF) remains the treatment of choice. Our surgical outcomes, while less favorable than IMF results, must be interpreted in context. The ORIF cohort inherently represented more complex injuries, often with greater displacement and comminution. Technical factors also influenced outcomes, as our series included cases treated with wire osteosynthesis alongside modern plating techniques [36]. Contemporary studies demonstrate that two-plate fixation systems, when properly applied, can achieve outcomes comparable to IMF for appropriate fracture patterns [37].

Several critical factors emerged as significant modifiers of treatment outcomes. The timing of intervention proved particularly important, with delayed treatment (>5 days' post-injury) correlating with poorer results across both treatment modalities [7]. The management of third molars in fracture lines also warrants careful consideration. While some controversy exists in the literature [38], our experience suggests that retained teeth contributed to delayed union in three of four affected IMF cases. We therefore recommend extraction of compromised teeth (mobile, carious, or partially erupted) while retaining only asymptomatic, fully impacted molars [39,40]. Complication rates were comparable between treatment groups (10.9% overall), though the nature of complications differed. Surgical cases predominantly experienced infection-related issues, including abscess formation and osteomyelitis [41], while conservative management was more

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associated with delayed union. This complication profile emphasizes the need for meticulous technique in ORIF cases, including strict asepsis and appropriate antibiotic prophylaxis [42]. For IMF cases, careful preoperative dental evaluation and selective tooth extraction appear crucial for optimizing outcomes [43]. Our study has several important limitations that must be acknowledged. The retrospective design introduces potential selection bias, particularly regarding treatment allocation. The relatively small surgical subgroup (n=33) limits the statistical power for certain comparative analyses. Additionally, the regional specificity of our patient population may affect generalizability to other practice settings [32]. Technical variability in surgical methods, ranging from wire fixation to modern plating systems, further complicates direct comparisons [11].

Conclusion

Our findings advocate for a fracture stability-driven treatment algorithm. Intermaxillary fixation (IMF) represents the treatment of choice for stable, non-displaced mandibular angle fractures, offering excellent union rates with minimal morbidity and significant cost-effectiveness in resource-limited settings like Libya, *when applied to appropriate cases with strict compliance monitoring via follow-ups and patient education*. Conversely, open reduction and internal fixation (ORIF) with two-plate fixation remains essential for displaced or unstable fractures. Outcomes for ORIF can be optimized through the use of modern fixation techniques, careful attention to surgical principles [37], and prioritizing surgical training in these contemporary methods over outdated techniques like wire fixation. Key clinical strategies to enhance overall success include timely intervention (<72 hours) and selective third molar management (extracting mobile or carious teeth). Preventive programs targeting high-risk populations are also recommended. To further refine treatment protocols, future research should focus on prospective randomized trials comparing contemporary ORIF methods with IMF in matched fracture types, alongside long-term functional assessments such as temporomandibular joint (TMJ) health and occlusion stability.

Conflict of interest. Nil

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