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Radiographic and Clinical Evaluation of Hardware Removal in Maxillofacial Trauma: Influence of Surgical Technique and Etiology

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ABSTRACT

Background: *Open reduction and internal fixation (ORIF) is widely used in the management of maxillofacial fractures because it provides stable fixation and allows early functional recovery. However, the presence of fixation hardware is not always free of complications. It can be observed in daily clinical practice that a proportion of patients later require hardware removal due to infection, exposure, pain, or other related complaints. The factors influencing this decision, particularly surgical technique and trauma etiology, remain a subject of ongoing discussion.*

Objective: *To evaluate the clinical and radiographic factors associated with hardware removal following ORIF in patients with maxillofacial trauma, with specific emphasis on the influence of surgical technique and trauma etiology.*

Materials and Methods: *A retrospective descriptive study was conducted at the Department of Oral and Maxillofacial Surgery, Military Hospital, Sana'a, Yemen, between January 2021 and December 2025. Medical records of patients who underwent hardware removal after previous ORIF were reviewed. Demographic data, trauma etiology, fracture site, type of fixation hardware, surgical approach, duration of hardware retention, and indications for removal were collected. Radiographic evaluation was performed using archived panoramic radiographs and computed tomography images. Statistical analysis was used to assess associations between infection-related hardware removal and relevant clinical variables.*

Results: *Out of 110 patients with a history of ORIF who were screened, 77 met the inclusion criteria and underwent hardware removal. Most patients were male, with the highest frequency observed in the 21–30-year age group. Gunshot and explosive injuries were the most common causes of trauma. Infection represented the most frequent indication for hardware removal, followed by pain and hardware exposure. Through analysis of the collected data, clear patterns emerged in relation to hardware type, surgical approach, and duration of retention.*

Conclusion: *Based on the above findings, surgical technique, trauma etiology, and prolonged hardware retention appear to play an important role in the need for hardware removal following maxillofacial fracture management. These results underline the importance of careful surgical planning and structured postoperative follow-up, particularly in settings with complex trauma patterns.*

Keywords

Maxillofacial Trauma, Younger patients, Soft-tissue closure.

Introduction

Maxillofacial trauma remains a major clinical problem due to its functional, aesthetic, and psychological consequences. Injuries to the facial skeleton can interfere with mastication, speech, and social interaction, and in severe cases may be associated with life-threatening conditions involving the airway, brain, or cervical spine [1-3]. In this context, open reduction and internal fixation (ORIF) has become a widely accepted treatment modality, as it allows accurate anatomical reduction and early restoration of function [4,5].

Despite the advantages of rigid internal fixation, the long-term presence of metallic hardware is not always without complications. It can be observed that while many patients tolerate fixation plates without symptoms, others later present with conditions that necessitate their removal. These conditions most commonly include infection, plate exposure, persistent pain, or patient discomfort [6-8]. As a result, the decision to remove fixation hardware is often complex and remains controversial within oral and maxillofacial surgery.

Through analysis of the literature, it is clear that reported rates of hardware removal after ORIF vary considerably. Some studies report relatively low removal rates, whereas others describe removal in a substantial proportion of patients [9-11]. This variation may partly be explained by differences in study design, patient populations, trauma severity, and follow-up protocols. In addition, opinions differ regarding the optimal management strategy. While some authors advocate routine removal of hardware after fracture healing, particularly in younger patients, others recommend removal only when clear clinical symptoms are present [12,13].

In this context, several factors have been identified as potentially influencing the need for hardware removal. Fracture site, trauma mechanism, surgical approach, type of fixation system, and duration of hardware retention have all been implicated [14-16]. In particular, the role of surgical technique has received increasing attention. Intraoral approaches have been associated with higher rates of infection and plate exposure in some studies, possibly due to thinner soft-tissue coverage and increased bacterial contamination. Extraoral approaches, on the other hand, may offer better visibility and more stable soft-tissue closure, although they carry the risk of external scarring [17-19].

The type of hardware used may also influence outcomes. Larger reconstructive plates are often required for complex or high-energy injuries and may be associated with higher complication rates, not only because of their size but also due to the severity of the underlying trauma [20,21]. In addition, prolonged retention of fixation hardware has been suggested to increase the risk of late infection or exposure in certain clinical situations.

In Yemen, and particularly in Sana'a, the pattern of maxillofacial trauma has been strongly influenced by ongoing armed conflict. High-energy injuries caused by gunshots and explosive devices are frequently encountered and often result in complex, comminuted fractures requiring extensive fixation [22,23]. Moreover, many patients initially receive ORIF at different institutions, with varying surgical standards and follow-up protocols. In this context, referral centers such as the Military Hospital in Sana'a commonly manage patients presenting later with hardware-related complications.

Based on the above considerations, the present study was designed to evaluate the clinical and radiographic characteristics of patients undergoing hardware removal after ORIF for maxillofacial trauma. Particular emphasis was placed on the influence of surgical technique and trauma etiology on infection-related hardware removal, as understanding these relationships may help guide surgical decision-making and improve postoperative care in similar clinical settings.

Materials and Methods

Study design and setting

This retrospective descriptive study was conducted at the Department of Oral and Maxillofacial Surgery, Military Hospital, Sana'a, Yemen. Patient records from January 2021 to December 2025 were reviewed. The hospital serves as a major referral center for maxillofacial trauma cases, including patients initially treated at other facilities.

Study population

Patients with maxillofacial trauma who had previously undergone ORIF and subsequently presented for hardware removal were considered eligible. A total of 110 patient records were initially screened. Of these, 77 patients fulfilled the inclusion criteria and had sufficient clinical and radiographic data for analysis.

Inclusion criteria

- Patients who underwent removal of fixation hardware following ORIF for maxillofacial fractures
- Treatment or follow-up at the Military Hospital, Sana'a
- Availability of adequate medical and radiographic records

Exclusion criteria

- Non-maxillofacial trauma cases
- Patients outside the defined study period
- Incomplete or insufficient clinical documentation

Data collection

Data were collected using a standardized checklist. Variables included age, sex, trauma etiology, fracture site, type of fixation hardware, surgical approach (intraoral, extraoral, or combined), duration of hardware retention, and the primary indication for removal. In this study, infection was defined clinically by the presence of purulent discharge at the surgical site.

Radiographic assessment was performed using archived panoramic radiographs and computed tomography scans. These images were reviewed to evaluate fracture healing, hardware position, and the presence of radiographic signs suggestive of complications.

Statistical analysis

Data were analyzed using IBM SPSS software. Descriptive statistics were used to summarize demographic and clinical characteristics. Associations between infection-related hardware removal and selected variables were assessed using appropriate statistical tests, with results expressed as odds ratios and p-values. Statistical significance was set at $p < 0.05$.

Results

Patient demographic and trauma-related characteristics

A total of 77 patients who underwent hardware removal following previous ORIF for maxillofacial trauma were included in the analysis, out of 110 screened records. The demographic characteristics of the study population are summarized in Table 1.

The majority of patients were male (98.7%, n = 76), while only one female patient (1.3%) was recorded. The age of the patients ranged from 11 to over 40 years. It can be observed that the 21–30-year age group represented the largest proportion of cases (49.4%, n = 38), followed by patients aged 11–20 years (22.1%, n = 17). Other age groups were less frequently represented.

Regarding trauma etiology, high-energy mechanisms were predominant. Gunshot injuries accounted for 40.3% (n = 31) of cases, followed by explosive-related injuries (31.2%, n = 24). Road traffic accidents and other causes constituted a smaller proportion of the study population.

Table 1: Demographic characteristics and trauma etiology of the study population (n = 77).

Variable	Frequency (n)	Percentage (%)
Sex		
Male	76	98.7
Female	1	1.3
Age group (years)		
11–20	17	22.1
21–30	38	49.4
31–40	14	18.2
>40	8	10.3
Trauma etiology		
Gunshot injury	31	40.3
Explosive injury	24	31.2
Road traffic accident	14	18.2
Other causes	8	10.3

Distribution of fracture sites

The distribution of fracture sites is presented in Table 2. Mandibular fractures were the most frequently involved site, accounting for 70.1% (n = 54) of cases. Fractures of the zygomatic region were observed in 16.9% (n = 13) of patients, while orbital fractures were recorded in 13.0% (n = 10). Maxillary fractures were identified in 11.7% (n = 9) of cases. Some patients presented with fractures involving more than one anatomical site.

Table 2: Distribution of maxillofacial fracture sites (n = 77).

Fracture site	Frequency (n)	Percentage (%)
Mandible	54	70.1
Zygomatic region	13	16.9
Orbit	10	13.0
Maxilla	9	11.7

Hardware characteristics and surgical approach

The types of fixation hardware and surgical approaches used are summarized in Table 3. Mini-plates were the most commonly removed hardware, accounting for 70.1% (n = 54) of cases. Reconstructive plates were removed in 26.0% (n = 20) of patients, while mesh or other fixation devices constituted a smaller proportion.

In terms of surgical approach, the extraoral approach was the most frequently recorded (55.8%, n = 43), followed by the intraoral approach (31.2%, n = 24). A combined intraoral and extraoral approach was used in 13.0% (n = 10) of cases.

The duration of hardware retention varied. The most common retention period was 7–12 months (29.9%, n = 23), followed by 13–24 months (26.0%, n = 20). Hardware retained for more than 24 months was documented in 20.8% (n = 16) of patients.

Table 3: Hardware type, surgical approach, and retention duration (n = 77).

Variable	Frequency (n)	Percentage (%)
Hardware type		
Mini-plates	54	70.1
Reconstructive plates	20	26.0
Mesh / other	3	3.9
Surgical approach		
Extraoral	43	55.8
Intraoral	24	31.2
Combined	10	13.0
Retention duration		
<7 months	18	23.4
7–12 months	23	29.9
13–24 months	20	26.0
>24 months	16	20.8

Indications for hardware removal

The clinical indications for hardware removal are shown in Table 4. Infection, defined by the presence of purulent discharge, was the most common indication (31.2%, n = 24). Pain without overt infection accounted for 27.3% (n = 21) of cases, while hardware exposure was recorded in 22.1% (n = 17). Removal based on patient request or discomfort was documented in 19.5% (n = 15) of patients.

Table 4: Indications for hardware removal (n = 77).

Indication	Frequency (n)	Percentage (%)
Infection	24	31.2
Pain	21	27.3
Hardware exposure	17	22.1
Patient request / discomfort	15	19.5

Factors associated with infection-related hardware removal

The associations between selected variables and infection-related hardware removal are presented in Table 5. Infection-related removal was analyzed in relation to fracture site, hardware type, surgical approach, and duration of hardware retention. Odds ratios

(ORs) and p-values were calculated to describe these associations.

Table 5: Factors associated with infection-related hardware removal.

Variable	OR	p-value
Mini-plates	0.2	0.002
Reconstructive plates	6.8	0.001
Extraoral approach	0.2	0.003
Intraoral approach	4.6	0.004
Combined approach	5.1	0.020
Retention >24 months	4.3	0.006
Orbital fracture	2.6	0.130

Discussion

The present study evaluated the clinical and radiographic characteristics of patients who underwent hardware removal following ORIF for maxillofacial trauma, with particular focus on surgical technique and trauma etiology. Through analysis of the collected data, several patterns can be observed that are relevant to everyday clinical decision-making in oral and maxillofacial surgery.

In this cohort, infection was the most common indication for hardware removal. This finding is consistent with previous reports, where infection has frequently been identified as the leading cause of plate removal after maxillofacial fracture fixation. In this context, it is clear that infection remains a major concern despite advances in fixation systems and surgical techniques. The relatively high proportion of infection-related removals observed in the present study may partly be explained by the nature of the trauma encountered, as a large percentage of patients sustained high-energy injuries caused by gunshots or explosive devices.

Trauma etiology appears to play an important role in the overall complication profile. High-energy mechanisms are often associated with extensive soft-tissue damage, contamination, and comminuted fractures, all of which may compromise local blood supply and wound healing. Based on the above, it is reasonable to assume that patients injured by gunshots or explosions are inherently at a higher risk of postoperative complications, including infection, regardless of the fixation method used. This observation is particularly relevant in conflict-affected settings, where delayed presentation and limited postoperative follow-up are common.

The type of fixation hardware was also strongly associated with infection-related removal. Reconstructive plates demonstrated a significantly higher odds of infection-related removal compared to mini-plates, whereas mini-plates appeared to have a protective association. This finding should be interpreted with caution. Larger reconstructive plates are typically used in more severe fractures, which themselves carry a higher risk of complications. Therefore, the observed association may reflect the severity of the underlying injury rather than the hardware alone. Nevertheless, the data suggest that whenever fracture stability allows, the use of smaller fixation systems may reduce the likelihood of late complications.

Surgical approach was another factor that showed a clear relationship with infection-related hardware removal. Intraoral and combined approaches were associated with higher odds of infection, while the extraoral approach appeared to be protective. It can be observed that intraoral approaches, although cosmetically favorable, are performed in a contaminated environment with thinner soft-tissue coverage. This may increase the risk of bacterial colonization and subsequent infection. Extraoral approaches, on the other hand, provide better visualization and allow more secure soft-tissue closure, which may explain the lower infection rates observed in this group.

Duration of hardware retention also emerged as a relevant factor. Hardware retained for more than 24 months was associated with a significantly increased risk of infection-related removal. Through analysis, it becomes clear that prolonged retention may allow for chronic low-grade infection or gradual soft-tissue breakdown, eventually leading to clinical symptoms. In settings where structured follow-up is limited, delayed presentation for hardware-related complications may further increase this risk.

Orbital fractures showed a non-significant trend toward higher infection-related removal. Although this association did not reach statistical significance, it may still be clinically relevant. Orbital hardware is often placed in anatomically complex regions with thin soft-tissue coverage, which may predispose to late exposure or infection. Larger studies may be required to clarify this relationship.

Several limitations of this study should be acknowledged. The retrospective design limits control over confounding variables, such as smoking status, systemic disease, and timing of antibiotic administration. In addition, many patients received their initial ORIF at different institutions, which introduced variability in surgical technique and postoperative care. Despite these limitations, the study provides valuable insight into hardware-related complications in a real-world clinical setting with complex trauma patterns.

Conclusion

Based on the findings of this study, infection remains the most common indication for hardware removal following ORIF in maxillofacial trauma patients. Surgical approach, type of fixation hardware, trauma etiology, and duration of hardware retention all appear to influence the likelihood of infection-related removal. Extraoral approaches and the use of mini-plates were associated with lower infection risk, whereas reconstructive plates and prolonged retention were associated with higher risk.

These results highlight the importance of careful surgical planning, appropriate selection of fixation systems, and structured postoperative follow-up, particularly in settings characterized by high-energy trauma and limited continuity of care.

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