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RESEARCH ARTICLE

ANALYSIS OF HARDWARE REMOVAL IN MAXILLOFACIAL TRAUMA: A RETROSPECTIVE STUDY IN A MILITARY HOSPITAL IN SANA'A, YEMEN

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Abstract

Background and objective: Dental trauma is a significant problem for total dental health in terms of expenses, frequency, and age (young patients). Collaboration between various professionals, including oral surgeons, maxillofacial surgeons, dentists, orthodontists, and periodontists, frequently results in the treatment process. Surgical treatment may entail placing plates for fractures and shattered bones for long or permanent periods, and may require their removal for many reasons. Therefore, this study sought to ascertain the reasons for plate removal in individuals referred to the Department of Oral and Maxillofacial Surgery at Military Hospital in Sana'a, Yemen during a period of 3 years.
Method: The study included 57 Yemeni patients who visited the Department of Oral and Maxillofacial Surgery at the Military Hospital in Sana'a during the period 2021-2023. Cases of hardware removal were extracted from the medical records to include sex, age, medical history, accident history, type of fracture, primary complaint, period from the date of the first operation, approach to the operation, tooth in the fracture line, and extracted tooth.
Results: Gunshot injuries (40.4%) and explosive injuries (31.6%) were the most common causes of maxillofacial fractures. Mandibular fractures (68.4%) were the most frequent, followed by orbital and zygomatic fractures (12.3% each). The main reason for hardware removal was infections (29.8%), followed by patient preference (22.8%) and visible exposed hardware (15.8%). Mini-plates (68.4%) were the most commonly removed hardware, and the extra-oral approach (56.1%) was the most frequently used for removal. There was a significant association between orbital fractures and the incidence of positive discharge, as well as between reconstructive plates and the incidence of positive discharge. Longer plate usage, exceeding 24 months, increased the probability of positive discharge. Tooth involvement and extraction were minimal.
Conclusion: Gunshot and explosive injuries were the main causes of maxillofacial fractures, while infections, patient preferences, visible exposed devices, and pain and discomfort were the main reasons for removal of devices. Mandibular fractures were the most common and orbital fractures carry a higher risk of infection, while small plates have shown lower rates of infection. Prolonged panel use beyond 24 months increased the probability of positive discharge.
Keywords: Complications, hardware removal, maxillofacial trauma, Sana'a city, Yemen.

INTRODUCTION

Maxillofacial fractures can happen for a number of reasons, such as car crashes, assaults, gunshot wounds, falls, and sports injuries. Age, sex, cultural norms, and socioeconomic level are among the variables that affect the occurrence of maxillofacial fractures, which differs between geographic regions[1]. The way a maxillofacial fracture is treated depends on the extent of the damage and where the fracture is. While ORIF may be required for more difficult fractures, such as those involving the zygoma or maxilla, closed reduction with maxillo-mandibular fixation (MMF) is frequently employed for the therapy of subcondylar fractures[2,3].

Combined open reduction and closed reduction techniques may also be used in treatment. Micro-plates, mini-plates, and macro-plates are the many forms of internal fixing techniques that are available. Fast stabilization and painless mastication are two of internal fixation's primary benefits[4]. There is an increased risk of problems, such as infection and malunion, when there is a long delay between the injury and the repair[5]. On the other hand, there are drawbacks to using plates. If left in situ, they obstruct further imaging procedures. The removal of the plate will need to be done surgically again in the event of screw loosening, perceptible plate, or plate fracture. Localized abscesses, the creation of fistulas, nonunion, and osteomyelitis are all brought on by contaminated hardware[4]. Numerous researchers state that the CMF region is regarded as a privileged location that doesn't always need hardware removal[6,7]. As an illustration, one-third of the diseased hardware instances at the extremities required hardware removal. This is in contrast to other sites[8]. The authors suggested that positive wound cultures, hardware exposure lasting longer than two weeks, or hardware loosening are signs that the hardware should be removed[9,10].

The Military Hospital is a trauma center located in downtown Sana'a, Yemen. It's Department of Oral and Maxillofacial Surgery is one of the best-equipped departments in the nation. This facility receives referrals for patients with maxillofacial injuries of all ages from different parts of the country. Dental trauma is a significant problem for total dental health in terms of expenses, frequency, and age (for young patients). Collaboration between various professionals, including oral surgeons, maxillofacial surgeons, dentists, orthodontists, and periodontists, frequently results in the treatment process. During surgical treatment, plates for fractures and shattered bones may need to be placed for extended periods of time or removed for a variety of reasons[5]. Consequently, over the course of three years, this study aimed to determine the causes of plate removal in patients referred to the Department of Oral and Maxillofacial Surgery at the Military Hospital in Sana'a, Yemen.

SUBJECTS AND METHODS

Study design: A retrospective study.

Study population: All patient records submitted to a military hospital between 2021 and 2023 that required plate removal comprise the target population.

Inclusion criteria: The study included records of patients who had undergone hardware removal in cases of maxillofacial trauma and whom admitted to the Military Hospital's Department of Oral and Maxillofacial Surgery during the period of 3 years (2021–2023).

Exclusion criteria: individuals with incomplete documentation or missing data required for analysis.

Sample size calculation: The time window was the most influential factor in determining the study sample size. As the final results showed, the sample size was sufficient because the majority of the results showed statistical significance.

Sampling method: The study included 57 Yemeni patients attending the Department of Oral and Maxillofacial Surgery at the Military Hospital in the city of Sana'a during the defined period of 2021–2023.The choice of this period was due to the presence and completeness of information in the hospital record for the selected cases. Patients who underwent the procedure of hardware removal were included in the study. All the patients included in the study were Yemenis.

Data collection and analysis: Analysis techniques were applied based on the medical records to include sex, age, medical history, accident history, type of fracture, primary complaint, length of operation from fracture date, type of tooth, operation approach, tooth in fracture line, and removed tooth (if applicable). The IBM SPSS Statistics version 13.0 software was utilized for conducting statistical analysis and presenting results in tables

Ethical considerations: No names or pictures of the patients are included in the data, and all data kept private.

RESULTS

Table 1 show the age and sex distribution of patients with maxillofacial trauma who arrived at the Military Hospital, Sana'a City, Yemen. Most patients were male, 98.2%, and only one female case was recorded. Considering the age group, the majority of patients were in the age group of 21-30 years, as their number reached 29 (50%), followed by the age group of 11-20 years (13, 22.8%), while it was less common for the age groups of 31-40 years group (12.3%) and 41-50 years (10.5%). Other age groups had no or no more than one case.

Table 1: Age and sex distribution of patients with maxillofacial trauma arriving at the military hospital.

Characters	Number (%)
Sex	
Male	56 (98.2)
Female	1 (1.8)
Age groups (years)	
0-10	1 (1.8)
11-20	13 (22.8)
21-30	29 (50)
31-40	7 (12.3)
41-50	6 (10.5)
51-60	1 (1.8)
>60	0 (0.0)
Total	57 (100)

Table 2 shows the medical history and etiology of maxillofacial fractures after trauma. Most patients were healthy (96.5%) and only 2 (3.5%) of the cases were medically compromised patients. Considering the etiology of fractures, gunshot injuries were the most common cause of maxillofacial fractures at 40.4%, followed by explosive injuries at 31.6%. The third main cause was traffic accidents at 24.6%, while other usual causes of such fractures amounted to only 3.5% of the total.

Table 3 shows the location of fractures in patients who underwent hardware removal and who suffered maxillofacial trauma. The most frequent fractures were mandibular fractures at a rate of 68.4%, followed by orbital and zygomatic fractures at a rate of 12.3% each. Also, 7% of patients sustained fractures of the upper jaw, while other usual maxillofacial fractures after trauma were not detected in present study. Table 4 shows the main complaint causing appliance removal in patients who suffered maxillofacial trauma in current study.

Table 2: Medical history and etiology of patients with maxillofacial trauma who arrived at the military hospital.

Characters	Number (%)
Healthy	55 (96.5)
Medically compromised	2 (3.5)
Etiology	
Gunshot injury	23 (40.4)
Explosive injury	18 (31.6)
Road traffic accidents	14 (24.6)
Others*	2 (3.5)
Total	57 (100)

About one-third of patients (29.8%) experienced infections indicated by the discharge of pus at the site of the device plates, which was the main reason for device removal in our patients. The second reason for removing hardware in our patients was patients' desire at 22.8%, followed by visible exposed hardware (15.8%), pain (14%) and discomfort (14%). Only one case (1.8%) was due to movement of part of the fracture and one (1.8%) due to the patient's growth. Table 5 shows the length of time before appliance removal in patients who experienced maxillofacial trauma. More than a third of our patients (31.6%) received devices at 7-12 months, followed by 13-24 months for 21.1%, and 15.8% after 1-6 months. Also, 14% received devices for 25-48 months. Only 1 patient had the devices removed in the first month of applying the plates and 2 (3.5%) continued for 61-84 months to wear the devices for this long period. Table 6 shows the types of appliances removed and the surgical approach among cases of maxillofacial trauma. Considering the types, mini-plates were the common type used in present study patients with 68.4% of the total, followed by reconstructive plate with 28.1% of patients; while the mesh is only used in two cases (3.5%).

Table 3: Location of fractures in patients who underwent hardware removal and who suffered maxillofacial trauma.

Location of fracture	Number (%)
Frontal fractures	0 (0.0)
Orbital fractures	7 (12.3)
NOE fractures	0 (0.0)
Maxillary fractures	4 (7)
Zygomatic fractures	7 (12.3)
Mandibular fractures	39 (68.4)
Panfacial fractures	0 (0.0)
Total	57 (100)

Table 4: Chief complaint causing hardware removal in patients who experienced maxillofacial trauma.

Chief complaint	Number (%)
Pus discharge	17 (29.8)
Pain	8 (14)
Discomfort	8 (14)
Exposed palpable hardware	9 (15.8)
Mobility of fracture segment	1 (1.8)
Patients desired	13 (22.8)
Elective in growing patients	1 (1.8)
Total	57 (100)

Considering the surgical approach, the extra-oral approach was the most common approach at 56.1%, followed by the intra-oral approach at 40.4%, while the combined approach was only used in two cases (3.5%). Table 7 shows the involved teeth and extracted teeth among appliance removal cases for maxillofacial trauma patients. Teeth were affected in only 2 (3.5) of the cases, while this did not occur in the rest of the patients. Regarding tooth extraction, only one (1.8%) of our patients included in the study had their tooth extracted.

Table 5: Time of hardware removal in patients who experienced maxillofacial trauma.

Time	Number (%)
1-29 days	1 (1.8)
1-6 months	9 (15.8)
7-12 months	18 (31.6)
13-24 months	12 (21.1)
25 -48 months	8 (14)
49 – 60 months	6 (10.5)
61-84 months	2 (3.5)
≥85 months	0 (0.0)
Total	57 (100)

Table 8 shows the association between the occurrence of discharge (infection), fracture location, plate type, and duration of instrumentation. There was a significant association between orbital fracture and the incidence of positive discharge for which the associated odds ratio was 6.7 times with a 95% *CI* equal to 1.1 to 39, with X^2 equal to 5.3 and a significant *p* value equal to 0.02. In addition there was no association between other sites of fracture and the incidence of positive discharge. Considering type of plate used, miniplates have a protective associated odds ratio equal to 0.7 with 95% *CI* equal to 0.05-0.67 with X^2 equal to 8.2 and significance *p* equal to 0.003.

Table 6: Types of hardware appliances removed and surgical approach among cases of maxillofacial trauma.

Types	Number (%)
Mini plates	39 (68.4)
Reconstructive plate	16 (28.1)
Mesh	2 (3.5)
Surgical Approach	
Intra-oral	23 (40.4)
Extra-oral	32 (56.1)
Combined	2 (3.5)
Total	57 (100)

Table 7: Tooth involved and tooth extracted among hardware removal cases of maxillofacial trauma patients.

Characters	Number (%)
Tooth involved	
Yes	2 (3.5)
No	55 (96.5)
Tooth extracted	
Yes	1 (1.8)
No	56 (98.2)
Total	57 (100)

However, there was a significant association between reconstructive plate and the incidence of positive discharge for which the associated odds ratio was 3.5 times with a 95% *CI* equal to 1.1 to 12.1, with X^2 equal to 4.3 and a significant *p* value equal to 0.03. Considering the duration of the plates used, there was a significant association between >24 months and the incidence of positive discharge for which the associated odds ratio was 3.6 times with a 95% *CI* equal to 1.1 to 12.1, with X^2 equal to 4.3 and a significant *p* value equal to 0.03. In contrast, the shorter the periods, the fewer infections.

Table 8: Association of discharge occurrence (infection) and sit of fracture, type of plates used, and duration of hardware appliance.

Factors	Positive discharge N (%)	*OR*	*95% CI*	X^2	*p*
Site of fracture					
Orbital fractures, n=7	5 (71.4)	6.7	1.1-39	5.3	0.02
Maxillary fractures, n=4	0 (0)	0	0-2.5	1.8	0.17
Zygomatic fractures, n=7	0 (0)	0	0-1.2	3.4	0.06
Mandibular fractures, n=39	12 (30.8)	1.2	0.33-39	0.05	0.81
Type of plate					
Miniplates, n=39	7 (18)	0.7	0.05-0.67	8.2	0.003
Reconstructive plate, n=16	8 (50)	3.5	1.1-12.1	4.3	0.03
Mesh, n=2	2 (100)	-1	0.6- -1	4.9	0.02
Duration of plate					
Less than 6 months, n=10	1 (10)	0.2	0.02-1.8	2.2	0.13
7-12 months, n=18	6 (33.3)	1.2	0.3-4.2	0.15	0.6
13-24 months, n=12	2 (16.7)	0.4	0.07-2	1.3	0.26
>24 months, n=16	8 (50)	3.6	1.1-12.1	4.3	0.03

DISCUSSION

Maxillofacial trauma represents a significant burden, often requiring surgical intervention for optimal management and functional restoration. Internal fixation has been widely recognized as the primary method for stabilizing maxillofacial fractures, yielding favorable outcomes. However, the question of whether the hardware used for internal fixation should be removed remains a subject of debate among healthcare professionals. The decision to remove hardware after maxillofacial fracture stabilization is not always straightforward. While some argue that hardware removal is necessary to prevent potential complications, others contend that it may be an unnecessary procedure with its own inherent risks. Understanding the underlying reasons for plate removal and evaluating whether it is truly required or merely a symptom of other factors is crucial in guiding clinical decision-making and optimizing patient care[1,2].

The prevalence rate of the current study was 68.7%, greater than the 15.1% of Daniels *et al.*, study in 2021. Also higher than 10%, 17%, and 20.6% of researchers[11,12]. In present study, a significant gender disparity was observed, with the majority of patients being male (98.2%), while only one female case was recorded. This finding is consistent with some previous studies that have reported a higher proportion of male patients. For example, males accounted for 94.6% of the cases, while females represented only 5.4% in Daniels *et al.*, study in 2021[12]. Male predominantity in the current study might be due to the fact that our center primarily treated war victims. In conflict situations, it is often the case that a larger proportion of casualties are male due to their higher involvement in combat-related activities.

In the current study, the majority of patients fell within the age group of 21–30 years, accounting for 50% of the cases. This was followed by the age group of 11–20 years, representing 22.8% of the patients. Conversely, the age groups of 31–40 years and 41–50 years had lower frequencies of 12.3% and 10.5%, respectively. Comparing these findings with other studies, there are variations in the age distribution of patients requiring plate removal, in which the 30- to 40-year-old age group was in the Pan and Patil study[13] and in the 16–30-year-old group in the Daniels *et al.*, study[12] and in the 31–40-year-old group in the Aramanadka *et al.*, study[4]. The demographics of the study population, the types and causes of fractures, and particular healthcare settings are some of the variables that may have an impact on these variations in age distribution between studies.

In the current study, the majority of patients undergoing hardware removal had a healthy medical background (96.5%), while a small proportion were medically compromised (3.5%). However, a different study found that none of their patients required the removal of plates due to their immunocompromised status[12]. Chronic systemic disorders or weakened immune systems increase a patient's risk of developing chronic osteomyelitis, which is known to be predisposed to trauma[14]. In the current study, the most common causes of fractures in cases undergoing

hardware removal were gunshot injuries (40.4%) and explosive injuries (31.6%). Traffic accidents accounted for 24.6% of the cases, while other usual causes were relatively rare, comprising only 3.5% of the total. These findings differ from those of other studies, where road traffic accidents (RTAs) were reported as the most common cause of maxillofacial fractures[4,12].

According to the latest data, mandibular fracture cases accounted for the majority of plate removal surgeries. This result is in line with other results that have been published[4,12,15]. Also, current study revealed that the main complaint leading to hardware removal in patients who suffered maxillofacial trauma was infection, which accounted for 29.8% of the cases. This finding aligns with the results of other studies that have also identified infection as the most commonly associated complication leading to hardware failure in trauma patients were infections[4,16,17,18]. Interestingly, in the current study, only one case (1.8%) was due to the patient's growth. These findings suggest that fracture movement and growth-related concerns were relatively less common reasons for hardware removal in our patient population. Comparing these findings to studies focusing on pediatric patients, in which growth restriction was identified as the most common reason for plate removal, followed by palpable plates and patients' requests, infection has been reported as a significant cause of mini-plate removal[4] which is in line with the recommendation to remove mini-plates within 2-3 months after fracture healing to avoid potential growth restriction[19].

The timing of appliance removal in patients who have experienced maxillofacial trauma is an important consideration for optimizing treatment outcomes. In present study, it was observed that more than a third of our patients (31.6%) underwent device removal between 7 and 12 months after the initial surgery. This was followed by 21.1% of patients who had their devices removed between 13 and 24 months and 15.8% who underwent removal within 1-6 months. Additionally, 14% of patients had their devices removed between 25 and 48 months. There were only a few cases where devices were removed earlier or worn for an extended period, with one patient (1.8%) having the devices removed in the first month and two patients (3.5%) continuing to wear the devices for 61–84 months. These findings align with other studies that have investigated the timing of hardware removal in maxillofacial trauma cases[4,15].

In the current study, the extra-oral approach was the most commonly utilized method, accounting for 71.9% of cases. Interestingly, current findings differ from another study that reported an increased incidence of plate removal in patients who underwent open reduction and internal fixation with an intra-oral surgical approach[20,21]. This disparity may be attributed to the specific etiologies of maxillofacial trauma encountered in present study in which GSI and explosive injuries with open wounds, was a significant proportion of our cases, often present with direct access to the fracture site. In this study, examination the relationship between the site of the fracture, the kind of plate, the length of instrumentation, and the incidence of discharge (infection) in maxillofacial fractures. It was found that a strong correlation between the frequency of positive discharge and orbital fractures. This connection had an odds ratio of 6.7 times, and the 95% confidence range covered values between 1.1 and 39. Given the *p*-value of 0.02. On the other hand, no discernible correlation was found between the occurrence of positive discharge and any other fracture site.

Overall, ocular fractures and the occurrence of positive discharge were shown to be significantly correlated in present study. While reconstructive plates and longer plate durations were linked to a higher prevalence of positive discharge, miniplates showed a protective effect. These results emphasize how crucial it is to manage and avoid postoperative infections in maxillofacial fractures by taking into account the fracture location, type of plate, and length of instrumentation. To confirm these correlations and direct clinical judgments when making decisions on patient treatment, more investigation is necessary. By elucidating the factors contributing to hardware removal, this study seeks to provide valuable insights into the decision-making process regarding post-operative management of maxillofacial trauma cases.

Limitations of the study

The study utilized a retrospective design, which introduces inherent limitations, including potential recall bias, incomplete documentation, and reliance on existing medical records. This could affect the accuracy and completeness of the data collected for analysis. The research was conducted at a single institution, which may limit the generalizability of the findings to other healthcare facilities with different patient populations, treatment protocols, and resources. Also the study did not include long-term follow-up information beyond hardware removal. Long-term data would be valuable in assessing patient outcomes, complications, and the overall effectiveness of hardware removal in the management of complications in maxillofacial trauma cases.

CONCLUSIONS

Gunshot and explosive injuries were the main causes of maxillofacial fractures requiring hardware placement, while infections, patient preference, visible exposed hardware, pain, and discomfort were the primary reasons for hardware removal. Mandibular fractures were the most frequently encountered, followed by orbital and zygomatic fractures. Mini-plates were the most commonly removed hardware, and the extra-oral surgical approach was the preferred technique. Orbital fractures carried a higher risk of infection, while mini-plates demonstrated lower infection rates compared to other plate types. Prolonged plate usage beyond 24 months increased the probability of positive discharge. Tooth involvement or extraction did not necessitate hardware removal.

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AUTHOR'S CONTRIBUTIONS

Sharaf Aldeen HMA: gathered and analyzed data. **Al-Rahbi LM:** data analysis, report drafting. **Al-Ashwal AA:** editing, review. **Abbas AMA:** data analysis and interpretations. **Al-Kibsi TAM:** writing, review, and editing. **Al-Shamahy HA:** supervision, review. The final manuscript was read and approved by all authors.

DATA AVAILABILITY

The data supporting the findings of this study are not currently available in a public repository but can be made available upon request to the corresponding author.

CONFLICT OF INTEREST

Regarding this work, there is no conflict of interest.

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