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REASONS FOR REMOVING TITANIUM PLATES IN TREATED MAXILLOFACIAL TRAUMATIZED PATIENTS

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Abstract

Background: Titanium plates are widely accepted as the reference standard for the internal fixation of maxillofacial fractures owing to their favourable biocompatibility and mechanical behaviour. Nevertheless, a meaningful share of patients ultimately undergo a second operation to have the hardware removed for one of several reasons. Clarifying how often, and for what reasons, titanium plates are taken out is important for refining postoperative care and improving outcomes. The present study set out to establish the frequency of the various indications for titanium plate removal in patients previously treated for maxillofacial trauma.

Methods: This cross-sectional study was carried out at the Department of Oral and Maxillofacial Surgery, Lady Reading Hospital, Peshawar, Pakistan, with data collected from January 2025 to May 2025. A total of 115 patients undergoing titanium plate removal after maxillofacial trauma were recruited by consecutive non-probability sampling. Information was gathered through structured patient interviews, clinical examination, and review of case records. The indications for removal were classified as patient-demanded removal, infection, pain (Visual Analogue Scale score greater than 3), and age factor. Every patient underwent preoperative radiographic evaluation comprising orthopantomography and a postero-anterior skull view. Analysis was performed in SPSS version 26; categorical data were summarised as frequencies and percentages, and continuous data as mean ± standard deviation or median with interquartile range. Stratification was undertaken for age, gender, diabetes, hypertension, hardware type, fracture site, and the interval between fixation and removal, with the post-stratification Chi-square or Fisher's exact test applied at the 5% significance level.

Results: The cohort of 115 patients had a mean age of 32.6 ± 11.8 years (range 18–65 years). Men made up 82.6% (n = 95) and women 17.4% (n = 20). Patient-demanded removal was the leading indication at 38.3% (n = 44), followed by infection at 27.8% (n = 32), pain at 20.9% (n = 24), and age factor at 13.0% (n = 15). The mandible was the commonest site of removal (66.1%, n = 76), with the parasymphysis predominating (27.8%, n = 32). Mini-plates represented 73.0% (n = 84) of removed hardware and micro-plates 27.0% (n = 31). Removal occurred at two months in 27.8% (n = 32) and at four months in 72.2% (n = 83) of cases. Hypertension was recorded in 17.4% (n = 20) and diabetes mellitus in 9.6% (n = 11). Significant associations emerged between fracture site and indication (χ^2 = 18.64, p = 0.028), with infection clustering in zygomaticomaxillary complex fractures, and between the removal interval and indication (χ^2 = 12.84, p = 0.005), with infection and pain dominating early removals and patient demand dominating later ones. No significant relationship was found between indication and age group (p = 0.389), gender (p = 0.689), hardware type (p = 0.511), hypertension (p = 0.612), or diabetes (p = 0.418).

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Conclusions: Patient demand was the most frequent reason for titanium plate removal in treated maxillofacial trauma patients, ahead of infection, pain, and age factor. Both the fracture site and the interval between fixation and removal were significantly associated with the indication for removal. These observations underline the value of thorough preoperative counselling, site-specific risk appraisal, and well-timed intervention in the care of patients carrying titanium hardware. Further work is needed to formulate evidence-based guidelines for removal and to improve patient outcomes.

INTRODUCTION

The treatment of maxillofacial trauma has changed markedly over recent decades, and internal fixation is now the preferred means of achieving anatomical reduction and functional stability of facial fractures [1]. Rigid internal fixation transformed clinical results by allowing precise rebuilding of the facial skeleton, earlier return of function, and better aesthetic outcomes than older approaches such as wire osteosynthesis and prolonged maxillomandibular fixation [2]. Of the fixation materials in use, titanium has become the dominant choice because of its outstanding biocompatibility, mechanical strength, and resistance to corrosion [2,3].

Titanium mini-plates and micro-plates are generally regarded as the reference standard for osteosynthesis in the craniomaxillofacial region [3,4]. Their advantages include high tensile strength, good ductility, an absence of toxicity, and excellent biocompatibility that derives from a stable, self-renewing titanium dioxide surface conferring corrosion resistance [4,5]. Titanium also does not interfere with routine imaging such as computed tomography or magnetic resonance imaging, which facilitates assessment of bone healing and long-term follow-up [3,5]. Such properties explain the broad uptake of titanium fixation since its introduction in the late 1980s [1,2].

Despite these established benefits, whether titanium plates should be routinely removed once the bone has united remains contested [2,5]. Some surgeons favour prophylactic removal of asymptomatic hardware to forestall later complications, while others argue that plates may be left indefinitely unless a clear indication for removal arises [6,7]. The debate reflects the recognition that, although titanium is biologically inert, its presence in the facial skeleton can be linked to complications that require a further operation [6,8].

Reported removal rates after maxillofacial trauma vary widely, from roughly 7% to 33.8% [5,7], reflecting differences in study populations, follow-up length, surgical technique, and institutional policy. In a five-year retrospective series from Pakistan, Mushtaq and colleagues recorded a removal rate of 26.87% among 521 patients treated by open reduction and internal fixation, with the mandible being the most frequent site (67.14%) [7]. Their indications comprised patient demand (34.28%), infection (27.14%), pain (20.71%), and age-related considerations (17.84%) [7].

Infection is among the most frequently reported reasons for removal in this region [2,5,8]. The oral and maxillofacial environment, exposed to oral flora and functional loading, may favour biofilm formation and delayed infective complications [8,9]. Although titanium resists corrosion, its presence in a non-sterile field can permit bacterial colonisation that leads to localised infection,

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abscess, or osteomyelitis [4,9]. Rallis and colleagues attributed about one-quarter of removals to infection in their four-year study [5].

Persistent pain or discomfort at the fixation site is another important indication [2,10]. Pain may stem from periosteal irritation, pressure on adjacent nerves, thermal sensitivity owing to the different conductivity of titanium and bone, or micromotion at the bone–plate interface [10,11]. The Visual Analogue Scale (VAS) is commonly used to grade pain, and scores above 3 are usually taken to indicate clinically meaningful discomfort that may justify removal [7,11].

Patient demand for removal in the absence of objective abnormality is an indication that has attracted growing attention [8,12]. Psychological distress about retained foreign material, perceived discomfort, aesthetic concerns where plates are palpable beneath thin soft tissue, and anxiety over possible long-term effects can all prompt such requests [12,13]. In a prospective series of 172 patients, Zahoor and colleagues found patient demand to be the leading indication, accounting for 76.7% of procedures [12], emphasising the relevance of patient perspectives and quality of life.

Age also influences removal decisions. In children, concern over growth disturbance and plate migration as the facial skeleton develops has led some surgeons to advise routine removal after healing [8,13]. Cremona and colleagues observed a clear fall in removal with age, from 83% in children aged six years or under to 24% in adolescents aged 13 to 16 years [14]. In older patients, changes in soft tissue thickness and elasticity may make plates more prominent and symptomatic over time [7,14].

The site of fixation has emerged as a key determinant of removal risk. The mandible, with its thin mucosal cover, heavy functional loads, and exposure to minor trauma, shows higher rates of plate-related complications and removal than the midface [2,5,7]. In a systematic review and meta-analysis, Piombino and colleagues identified mandibular placement and tobacco use as significant risk factors for removal [2]. Likewise, Gul and colleagues reported that mandibular plates made up 63% of removed hardware in a prospective cohort of 420 patients, with pain (70%) and infection (91%) the leading indications [15].

The timing of removal also varies in practice. Some authors recommend removal once healing is complete, typically after six to twelve months, whereas others favour longer retention unless complications occur [6,11]. Optimal timing must weigh the wish to limit hardware exposure against the risks of a second operation and possible relapse or re-fracture if removal is premature [10,11]. Removal surgery itself carries risks, including additional anaesthesia, pain, infection, bleeding, nerve injury, and reduced bony stability, and may be technically demanding because of bony overgrowth, screw stripping, or plate fracture [6,11,13,15].

Despite how often removal is performed, consensus is lacking on its indications, optimal timing, and the factors predicting which patients will need it [2,5]. The literature is heterogeneous in design, outcome measures, and populations, limiting both generalisability and the development of guidelines [1,2]. In Pakistan, trauma is a major public health burden, with road traffic collisions a leading cause of maxillofacial injury, especially in young adult men [7,16]. Lady Reading Hospital, Peshawar, is a principal tertiary referral centre for Khyber Pakhtunkhwa and manages a high volume

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of such cases [7]. Understanding local patterns and reasons for removal is therefore essential for optimising care, improving outcomes, and allocating resources [5,15].

Accordingly, this study was undertaken to systematically evaluate the frequency and specific reasons for titanium plate removal in treated maxillofacial trauma patients at our centre. By quantifying the relative contributions of infection, pain, patient demand, and age-related factors, we aimed to generate evidence that can guide clinical decisions, inform counselling, and potentially reduce secondary interventions, while also identifying high-risk patients who might benefit from closer surveillance or alternative strategies [2,5,7,15]. The findings are intended to add to the literature on hardware management and to assist the development of locally relevant protocols [1,2,7].

Methods

Study design

A cross-sectional study was conducted at the Department of Oral and Maxillofacial Surgery, Lady Reading Hospital, Peshawar, Pakistan. Data were collected over a period of five months, from January 2025 to May 2025, following approval of the synopsis.

Setting

The work was carried out in the Department of Oral and Maxillofacial Surgery at Lady Reading Hospital, a major tertiary care referral centre serving the Khyber Pakhtunkhwa province of Pakistan. The department manages a high volume of maxillofacial trauma and routinely performs open reduction and internal fixation using titanium plating systems.

Participants

The study population comprised patients presenting for removal of titanium plates after previous surgical treatment of maxillofacial trauma. Patients of either gender, aged 18 to 65 years, who underwent removal with documented indications — infection confirmed on radiography, pain (VAS greater than 3), or compromised bone healing evident on radiography — were eligible.

Patients were excluded if they had sustained gunshot injuries, had infected fractures at the time of initial surgery, had comminuted fractures requiring complex reconstruction, or had pathological fractures secondary to underlying bone disease. To limit confounding of healing and complication rates, patients with uncontrolled diabetes mellitus, prolonged steroid therapy, or compromised immune status were also excluded.

Sample size

The sample size was calculated with the World Health Organization sample size calculator, based on the prevalence of age factor as a reason for removal (17.84%) reported by Mushtaq and colleagues [7]. With a 95% confidence level and a 7% margin of error, the minimum required sample was **115 patients**.

Sampling technique

Consecutive non-probability sampling was used. All eligible patients presenting during the study period were enrolled consecutively until the required sample size was reached.

Variables

The primary outcome was the reason for titanium plate removal, categorised as:

Demanded plate removal: removal driven by the patient's psychological distress and perceived discomfort over the presence of hardware, in the absence of objective clinical or radiographic abnormality.

Infection: defined on clinical evaluation by features such as localised swelling (VAS greater than 2) and pain (VAS greater than 3) at the surgical site, together with radiographic evidence of abscess formation or osteomyelitis.

Pain: assessed with the VAS, scored from 0 (no pain) to 10 (worst possible pain), and recorded as positive when the score exceeded 3.

Age factor: advancing age influencing the patient's perception of aesthetics and function such that removal became a necessary intervention for improved well-being.

Secondary variables comprised hardware type (mini-plates versus micro-plates), fracture site (mandible, maxilla, or zygomaticomaxillary complex), the interval between initial surgery and removal, diabetes mellitus, hypertension, age in years, and gender.

Data sources and measurement

Data were obtained through structured patient interviews, clinical examination, and review of medical records. Preoperative radiographic assessment, including orthopantomography and postero-anterior skull views, was performed for every patient to evaluate healing and detect any hardware-related pathology. Infection was assessed clinically by local signs of inflammation — swelling, erythema, warmth, and purulent discharge. Pain severity was quantified using a standard 10-cm VAS with anchor statements at each end, on which patients marked the point representing their current pain. All assessments were supervised by a consultant oral and maxillofacial surgeon with at least five years of post-fellowship experience to ensure consistent and accurate diagnosis and classification.

Bias

Selection bias was minimised by strict adherence to the predefined inclusion and exclusion criteria throughout recruitment. Information bias was addressed by using standardised, validated tools, including the VAS for pain. All clinical evaluations followed uniform diagnostic criteria as set out in the operational definitions, and observer bias was reduced by having a single consultant verify all assessments.

Vol. 5 No. 2 (2026)

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Amin et al - 2026

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Quantitative variables

Continuous variables (age and pain scores) were recorded numerically. Age was analysed both continuously (mean with standard deviation, or median with interquartile range according to distribution) and categorically for stratification. Pain scores were analysed continuously for description and dichotomously (present or absent) using the cut-off of greater than 3. Categorical variables — reason for removal, hardware type, fracture site, removal interval, diabetes, hypertension, and gender — were expressed as proportions and percentages.

Statistical methods

Data were entered and analysed in the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics were computed for all variables, with frequencies and percentages for categorical variables. The Shapiro–Wilk test assessed the normality of continuous variables such as age; normally distributed data were presented as mean ± standard deviation and non-normally distributed data as median with interquartile range. To address potential effect modification, stratification was performed for age, gender, diabetes, hypertension, hardware type, fracture site, and removal interval. After stratification, the Chi-square test compared the proportions of reasons across strata, with Fisher's exact test used where expected cell frequencies were below five. A p-value below 0.05 was regarded as statistically significant.

Ethical considerations

Approval was obtained from the Institutional Ethical Review Committee of Lady Reading Hospital MTI [Ref: No. 90.1/LRH/MTI] before commencement, and the study followed the principles of the Declaration of Helsinki. Each patient received detailed information about the purpose, procedures, potential risks, and anticipated benefits of the study in their preferred language (Urdu, Pashto, or English), and written informed consent was obtained before enrolment. Confidentiality and anonymisation of all data were assured, participation was voluntary, and patients were informed of their right to withdraw at any time without effect on their clinical care.

Results

Participant flow and recruitment

During the study period from January 2025 to May 2025, 128 patients presenting for titanium plate removal after maxillofacial trauma were assessed for eligibility. Thirteen were excluded under the predefined criteria: five with a history of uncontrolled diabetes mellitus, four with gunshot injuries, two with pathological fractures, and two who declined to participate. The remaining 115 patients were enrolled and included in the final analysis.

Demographic and clinical characteristics

The 115 patients had a mean age of 32.6 ± 11.8 years (range 18–65 years). Most were male (82.6%, n = 95), with females accounting for 17.4% (n = 20), giving a male-to-female ratio of about 4.8:1.

Vol. 5 No. 2 (2026)

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The largest age band was 26–35 years (35.7%, n = 41), followed by 18–25 years (27.8%, n = 32); patients aged 36–45, 46–55, and 56–65 years made up 20.9% (n = 24), 9.6% (n = 11), and 6.1% (n = 7), respectively.

Hypertension was documented in 17.4% (n = 20) of patients and diabetes mellitus in 9.6% (n = 11). Mini-plates were the most commonly removed hardware (73.0%, n = 84), with micro-plates accounting for 27.0% (n = 31). The mandible was the predominant site of removal (66.1%, n = 76), and the parasymphysis was the leading mandibular subsite. Midfacial removals comprised 33.9% (n = 39) of cases. Removal was performed at two months in 27.8% (n = 32) and at four months in 72.2% (n = 83) of patients. These demographic and clinical characteristics are summarised in Table 1.

Table 1 Demographic and clinical characteristics of patients undergoing titanium plate removal (N = 115)

Characteristic	Frequency (n)	Percentage (%)
Age group (years)		
18–25	32	27.8
26–35	41	35.7
36–45	24	20.9
46–55	11	9.6
56–65	7	6.1
Gender		
Male	95	82.6
Female	20	17.4
Comorbidities		
Hypertension	20	17.4
Diabetes mellitus	11	9.6
Type of hardware		
Mini-plates	84	73.0
Micro-plates	31	27.0
Fracture site		
Mandible	76	66.1
Maxilla	10	8.7

Vol. 5 No. 2 (2026)

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Amin et al - 2026
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Characteristic	Frequency (n)	Percentage (%)
Zygomaticomaxillary complex	22	19.1
Fronto-zygomatic region	7	6.1
Time frame to removal		
Two months	32	27.8
Four months	83	72.2

The detailed anatomical distribution of removal sites is shown in Fig. 1. Within the mandible, the parasymphysis was the most frequent subsite (27.8%, n = 32), followed by the angle (20.0%, n = 23), body (13.0%, n = 15), and condyle (5.2%, n = 6). Among midfacial sites, the zygomaticomaxillary complex predominated (19.1%, n = 22), followed by the maxilla (8.7%, n = 10) and the fronto-zygomatic region (6.1%, n = 7).

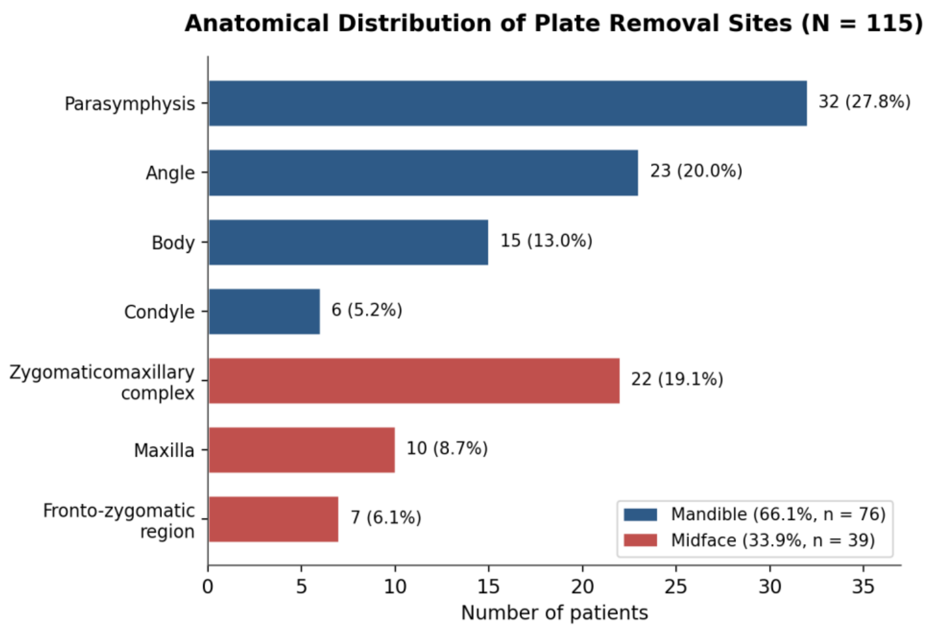

Fig. 1. Anatomical distribution of plate removal sites.

The horizontal bar chart depicts the anatomical sites from which fixation plates were removed among 115 patients. Mandibular sites accounted for the majority of removals (66.1%, n = 76), with the parasymphysis the most frequently involved subsite (27.8%, n = 32), followed by the angle (20.0%, n = 23), body (13.0%, n = 15), and condyle (5.2%, n = 6). Midfacial removals comprised 33.9% (n = 39), predominantly the zygomaticomaxillary complex (19.1%, n = 22), maxilla (8.7%, n = 10), and fronto-zygomatic region (6.1%, n = 7).

Vol. 5 No. 2 (2026)
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Amin et al - 2026
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Reasons for titanium plate removal

Patient-demanded removal was the most frequent indication, recorded in 38.3% (n = 44) of cases. Infection was second at 27.8% (n = 32), followed by pain at 20.9% (n = 24) and age factor at 13.0% (n = 15). This distribution is illustrated in Fig. 2.

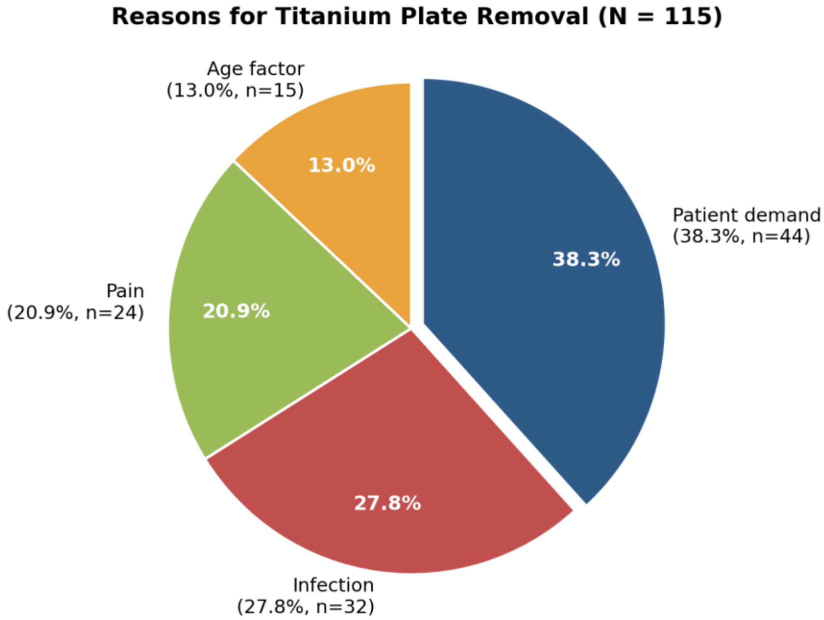

Fig. 2. Reasons for titanium plate removal in treated maxillofacial trauma patients.

The pie chart shows the indications for titanium plate removal among 115 patients. Patient demand was the most common reason (38.3%, n = 44), followed by infection (27.8%, n = 32) and persistent pain (20.9%, n = 24). Age-related factors were the least common indication (13.0%, n = 15). Among patients removed for infection, all (100%, n = 32) had localised swelling, 87.5% (n = 28) reported pain with a VAS above 3, and 62.5% (n = 20) had purulent discharge; radiographic abscess formation was seen in 21.9% (n = 7) and osteomyelitis in 9.4% (n = 3). For those removed because of pain, the mean VAS score was 6.2 ± 1.4 (range 4–9), indicating moderate intensity. Where removal was patient-demanded, the reasons cited were psychological distress over retained foreign material (59.1%, n = 26), perceived discomfort without objective findings (27.3%, n = 12), and aesthetic concern related to plate palpability (13.6%, n = 6).

Stratification of reasons by demographic and clinical factors

Stratified analysis examined the distribution of indications across demographic and clinical variables. No significant association was found between indication and age group ($\chi^2 = 8.47$, $p = 0.389$), gender (Fisher's exact, $p = 0.689$), or hardware type ($\chi^2 = 2.31$, $p = 0.511$). Likewise, neither hypertension

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

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(p = 0.612) nor diabetes mellitus (p = 0.418) was significantly associated with the reason for removal, although infection accounted for the highest proportion of removals among diabetic patients (45.5%, n = 5).

In contrast, two factors showed significant associations with the indication for removal: fracture site and the interval between fixation and removal (Table 2, Fig. 3). For fracture site, infection was the leading reason in zygomaticomaxillary complex fractures (31.8%), whereas patient demand predominated in fronto-zygomatic region fractures (71.4%) and in mandibular fractures (39.5%); this association was significant ($\chi^2 = 18.64$, p = 0.028). For the removal interval, infection (40.6%) and pain (31.3%) dominated removals performed at two months, while patient demand became the leading indication at four months (45.8%), a difference that was also significant ($\chi^2 = 12.84$, p = 0.005).

Table 2 Reasons for titanium plate removal stratified by fracture site and time frame (N = 115)

Stratum	Demanded removal n (%)	Infection n (%)	Pain n (%)	Age factor n (%)	Total n (%)
By fracture site ($\chi^2 = 18.64$, p = 0.028*)					
Mandible	30 (39.5)	22 (28.9)	17 (22.4)	7 (9.2)	76 (100)
Maxilla	3 (30.0)	2 (20.0)	3 (30.0)	2 (20.0)	10 (100)
ZMC	6 (27.3)	7 (31.8)	4 (18.2)	5 (22.7)	22 (100)
Fronto-zygomatic	5 (71.4)	1 (14.3)	0 (0.0)	1 (14.3)	7 (100)
By time frame ($\chi^2 = 12.84$, p = 0.005*)					
Two months	6 (18.8)	13 (40.6)	10 (31.3)	3 (9.4)	32 (100)
Four months	38 (45.8)	19 (22.9)	14 (16.9)	12 (14.5)	83 (100)
Overall total	**44 (38.3)**	**32 (27.8)**	**24 (20.9)**	**15 (13.0)**	**115 (100)**

*ZMC, zygomaticomaxillary complex. *Statistically significant at $p < 0.05$. Test of association: Chi-square test.*

Vol. 5 No. 2 (2026)
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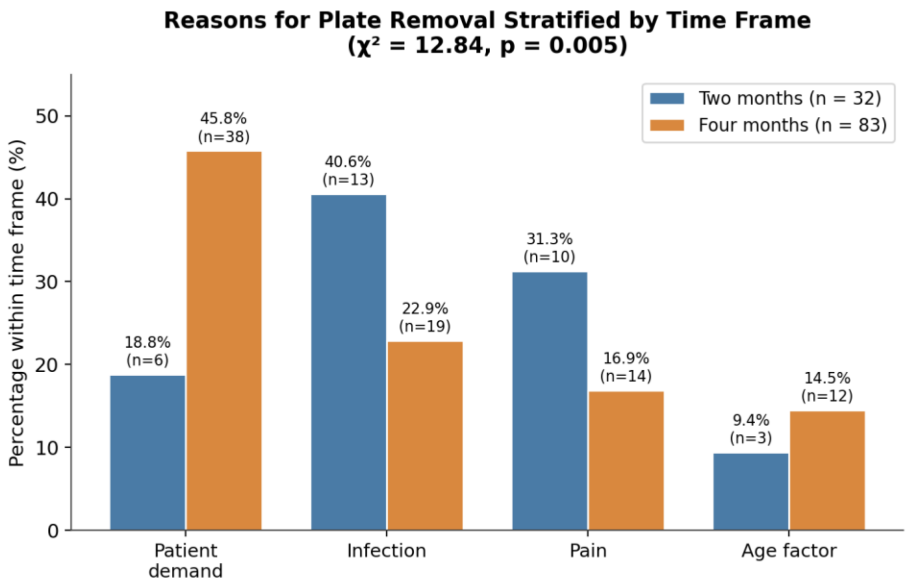

Fig. 3. Reasons for plate removal stratified by time frame.

The grouped bar chart shows the distribution of indications for removal at two months (n = 32) and at four months (n = 83) after fixation. At two months, infection was the predominant reason (40.6%), followed by pain (31.3%), patient demand (18.8%), and age factor (9.4%). At four months, patient demand became the most frequent indication (45.8%), while infection (22.9%), pain (16.9%), and age factor (14.5%) were less common. The distribution differed significantly between the two intervals ($\chi^2 = 12.84$, $p = 0.005$), indicating a temporal shift in the indications for removal.

Discussion

This cross-sectional study examined the frequency and reasons for titanium plate removal in 115 patients previously treated for maxillofacial trauma at a tertiary centre in Pakistan over a five-month period from January 2025 to May 2025. Patient-demanded removal was the leading indication (38.3%), followed by infection (27.8%), pain (20.9%), and age factor (13.0%). Significant associations were found between fracture site and indication ($p = 0.028$) and between the removal interval and indication ($p = 0.005$). These results add to the literature on hardware management and carry practical implications for clinical care and patient counselling.

The predominance of patient demand as the leading indication (38.3%) is consistent with several recent reports. Zahoor and colleagues described an even higher proportion (76.7%) in a prospective Pakistani series of 172 patients [12], while Mosbah and colleagues found patient request accounted for 41% of removals in their retrospective analysis [10]. The high frequency in our population may reflect greater patient awareness, cultural attitudes towards retained foreign material, and possibly insufficient preoperative counselling about long-term hardware retention [17]. Naghipur and

Vol. 5 No. 2 (2026)
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Amin et al - 2026
3007-2387 3007-2379
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colleagues likewise noted that younger patients more often requested removal for aesthetic reasons, particularly where plates were palpable in visible facial areas [18].

Psychological distress over retained foreign material was the commonest stated reason among patients requesting removal (59.1%). This accords with Bhatt and colleagues, who reported that 52% of such patients voiced anxiety about "metal left inside their body" [13]. The psychological burden of retained hardware should not be underestimated, since it can affect quality of life and satisfaction with surgery [19]. Riekert and colleagues, in a cohort of 289 midface fracture patients, similarly stressed the importance of patient-reported outcomes when deciding on prophylactic removal [6].

Infection was the second most frequent indication (27.8%), close to the 27.14% reported by Mushtaq and colleagues from the same institution [7] and the 24% recorded by Rallis and colleagues, who also noted a higher prevalence in mandibular than midfacial fractures [5]. We observed the same mandibular predilection, with mandibular fractures accounting for 28.9% of infection-related removals, likely reflecting thin mucosal cover, proximity to oral flora, and greater functional loading that promotes micromotion and biofilm formation [20]. The pathogenesis is multifactorial: although titanium is highly biocompatible, it is not immune to colonisation, and Veziroglu and colleagues showed that Staphylococcus aureus and other oral pathogens can adhere to titanium and form biofilms in the presence of salivary and serum glycoproteins [4,21,22]. Once established, such biofilm infections are difficult to clear with antibiotics alone and often require removal [23]. In our series, 62.5% of infected patients had purulent discharge and 21.9% had radiographic abscess formation, underlining the severity of these complications.

Pain accounted for 20.9% of removals, with a mean VAS of 6.2 ± 1.4, in keeping with the 20.71% of Mushtaq and colleagues [7] and the 18% of O'Connell and colleagues [11]. Hardware-related pain may arise from periosteal irritation, nerve compression or entrapment, thermal sensitivity, and micromotion at the bone–plate interface [24]. Pain was more often reported by younger patients (18–25 years: 28.1%) and in mandibular fractures (22.4%), possibly reflecting higher functional demand and greater soft tissue mobility.

Age factor accounted for 13.0% of removals, somewhat lower than the 17.84% of Mushtaq and colleagues [7], a difference perhaps attributable to variation in age distribution or in the definition of age-related indications. In children, removal is often motivated by concern over growth disturbance and plate migration [8,25], and Cremona and colleagues demonstrated a clear age-dependent decline in removal, from 83% in the youngest children to 24% in older adolescents [14]. In older adults, soft tissue changes may make plates more prominent and symptomatic, prompting removal for comfort or aesthetics [26].

The mandibular predominance of removal sites (66.1%) aligns with the literature. Piombino and colleagues, pooling 18 studies and 3,847 patients, identified mandibular placement as a significant risk factor for removal (OR = 2.84, 95% CI 1.92–4.21) [2]. The parasymphysis was our commonest mandibular subsite (27.8%), likely reflecting thin soft tissue cover and the high incidence of parasymphysis fractures locally [16]. Gul and colleagues similarly reported mandibular plates as 63% of removed hardware in 420 patients [15].

Vol. 5 No. 2 (2026)
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Amin et al - 2026
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The significant association between fracture site and indication (p = 0.028) warrants comment. Infection was commoner in zygomaticomaxillary complex fractures (31.8%), possibly because of their proximity to the paranasal sinuses and the potential for sinusitis to involve the hardware [27]. Conversely, patient demand was highest in fronto-zygomatic region fractures (71.4%), likely owing to the superficial position of hardware and resulting palpability and aesthetic concern [28]. These site-specific patterns should inform counselling and follow-up.

The association between removal interval and indication (p = 0.005) revealed distinct patterns: infection and pain dominated early removals (two months), whereas patient demand led later removals (four months). This is biologically plausible, since infective complications typically present within the first months before soft tissue healing and stable vascularity are established [29]. Kim and colleagues reported that 78% of infection-related removals occurred within three months of surgery [30], while patient-demanded removals tend to occur later, once patients have had time to reflect on hardware-related sensations and concerns [31].

The absence of a significant association between hardware type and indication (p = 0.511) suggests that mini-plates and micro-plates carry similar complication profiles when appropriately used, consistent with Aramanadka and colleagues, who found no difference in removal rates between the two systems in 521 patients [1]. The smaller micro-plate subgroup (n = 31), however, limits statistical power. Regarding comorbidity, infection accounted for 45.5% of removals in diabetic patients versus 23.8% in those without comorbidities, though without statistical significance (p = 0.418), again likely reflecting the small diabetic subgroup (n = 11) [32,33].

The removal rate at our institution (26.87% of operated patients, as previously reported by Mushtaq and colleagues [7]) lies within the wide international range of 7% to 33.8% [5,34]. The upper part of this range, including our findings, may partly reflect the inclusion of patient-demanded removals, which are not uniformly reported elsewhere [35]. Any decision to remove hardware must balance symptom relief and patient concerns against the risks of a further operation — infection, bleeding, nerve injury, anaesthetic risk, and possible loss of bony stability or re-fracture if removal is premature [6,36,37]. No major complications occurred during removal in our series, in keeping with the generally favourable safety profile of the procedure [38].

Strengths of this study include its standardised data collection using validated instruments, strict eligibility criteria, comprehensive stratified analysis, and conduct at a high-volume tertiary centre, which supports generalisability to similar regional settings [39]. The inclusion of both plate types and detailed subsite analysis provides granular data for site-specific decision-making [40]. Limitations include the single-centre design, which may restrict generalisability; the consecutive non-probability sampling, which carries some risk of selection bias despite strict criteria; limited statistical power in small subgroups such as diabetic patients and fronto-zygomatic fractures; the cross-sectional design, which precludes causal inference; the subjectivity of the patient-demand indication, influenced by culture, counselling quality, and psychological profile, none of which was systematically measured; and the absence of long-term outcome data such as satisfaction, functional recovery, and quality of life [41,42].

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Amin et al - 2026
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Comparison with international data shows both convergence and divergence. Our 38.3% rate of patient-demanded removal exceeds the 12–15% of some European series [5,6] but is below the 76.7% of another Pakistani study [12], differences that may reflect cultural attitudes to retained hardware, healthcare and follow-up practices, and methodology [43]. Our infection rate (27.8%) is comparable with the 24–30% range of most series [2,5,44], suggesting that infective complications are relatively consistent across populations.

The clinical implications are several. The high rate of patient-demanded removal highlights the need for thorough preoperative counselling on the expected duration of retention, the rationale for leaving plates in situ, and the possible indications for future removal [45]. The site-specific association supports tailoring postoperative monitoring to fracture location [46], and the temporal pattern can guide patient education about when different complications are likely to arise [47]. The substantial contribution of infection reinforces the importance of meticulous technique, appropriate antibiotic prophylaxis, and vigilant surveillance [48]. Future work should include multicentre prospective studies with larger samples to strengthen stratified analyses, longitudinal assessment of patient-reported outcomes after removal, randomised trials comparing routine with selective removal in asymptomatic patients, and studies of the psychological drivers of patient demand and the effect of counselling on reducing unnecessary removals [49–52].

Conclusion

Patient demand was the most frequent indication for titanium plate removal in treated maxillofacial trauma patients at our institution, ahead of infection, pain, and age factor. Both the fracture site and the interval between initial surgery and removal were significantly associated with the indication for removal. These findings emphasise the importance of individualised counselling, site-specific risk assessment, and appropriate timing of intervention in managing patients with titanium hardware. Further research is needed to develop evidence-based guidelines for removal and to optimise patient outcomes.

Declarations

Ethics approval and consent to participate

Approval was obtained from the Institutional Ethical Review Committee of Lady Reading Hospital MTI [Ref: No. 90.1/LRH/MTI] before commencement, and the study adhered to the Declaration of Helsinki. All patients received information about the study in their preferred language (Urdu, Pashto, or English) and provided written informed consent before enrolment. Confidentiality and anonymisation were assured, participation was voluntary, and patients could withdraw at any time without affecting their care.

Consent for publication

Not applicable. This manuscript contains no individual person's data in any form requiring consent for publication; all data presented are aggregated and anonymised.

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Amin et al - 2026
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Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request. Data are held in password-protected files at the Department of Oral and Maxillofacial Surgery, Lady Reading Hospital, Peshawar. Access to raw data may be granted subject to institutional data-sharing policies and ethical approval conditions.

Competing interests

The authors declare that they have no competing interests. No author has any financial relationship with any commercial entity producing titanium plating systems or any other product mentioned in this study.

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Authors' contributions

NA (Nazish Amin): conception and design, data acquisition, clinical examination of patients, data analysis and interpretation, and drafting of the manuscript. TUK (Tahir Ullah Khan): conception and design, supervision of clinical assessments, verification of diagnoses, data interpretation, critical revision of the manuscript, and corresponding author. NS (Noorulain Sajjad): patient recruitment, informed consent process, data collection, follow-up assessments, literature review, and manuscript preparation. GA (Gulfam Ali): data acquisition, clinical examination, radiographic assessment, assistance with analysis, and manuscript editing. NK (Numan Khan): statistical analysis, data interpretation, figure preparation, and manuscript editing. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

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Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

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