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Symptomatic plate removal after treatment of facial fractures☆

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SUMMARY. Aims: **To identify the rates and reasons for plate removal (PR) among patients treated for facial fractures.** Materials and methods: **A retrospective review of files of 238 patients.** Results: **Forty-eight patients (20.2%) had plates removed. The reason for removal was objective in 33.3% and subjective in 29.2%. The most common subjective reason was cold sensitivity, and the most common objective reason was wound dehiscence/infection. Women had PR for subjective reasons more often than men ($p = 0.018$). Removal was performed more often for subjective reasons after zygomatico-orbital fractures than after mandibular fractures ($p = 0.002$). Plates inserted in the mandible from an intraoral approach were removed more frequently than extraorally inserted mandibular plates, intraorally inserted maxillary plates, and extraorally inserted plates in other locations ($p < 0.001$). Orbital rim plates had a higher risk of being removed than maxillary or frontal bone plates ($p = 0.02$).** Conclusions: **Subjective discomfort is a notable reason for PR among Finnish patients, suggesting that the cold climate has an influence on the need for removal. Patients receiving mandibular osteosynthesis with miniplates from an intraoral approach are at risk of hardware removal because of wound dehiscence/infection and loose/broken hardware, reminding us that more rigid fixation devices should not be forgotten despite the widespread use of miniplates. © 2010 European Association for Cranio-Maxillo-Facial Surgery**

Keywords: **Plate removal, osteosynthesis material removal, facial trauma, facial fracture**

INTRODUCTION

Recently published studies that have focused on facial trauma patients reveal fairly similar results with regard to hardware removal rates. Some 20–30% of patients eventually need to have their plates removed (*Islamoglu* et al., 2002; *Nagase* et al., 2005; *Bakathir* et al., 2008), most often because of infections or other complications in the surgical area (*Islamoglu* et al., 2002; *Murthy* and *Lehman*, 2005; *Rallis* et al., 2006; *Bakathir* et al., 2008). Subjective discomfort, on the other hand, only rarely leads to plate removal (PR) (*Murthy* and *Lehman*, 2005; *Bakathir* et al., 2008).

Several factors may increase the risk of subjective discomfort and subsequent need for PR. A study from Canada showed that the great majority of PRs were performed because of subjective discomfort, which according to the authors was possibly provoked by the cold climate (*Nagase* et al., 2005). As weather conditions are similar in Finland, it can be presumed that a significant proportion of Finnish patients request hardware removal because of symptoms that cause discomfort during the winter months.

The purpose of the present study was to identify rates of and reasons for PR among patients who have been treated for facial fractures. An additional aim was to clarify the factors that predispose to PR, the main hypothesis being that plates are removed frequently because of subjective symptoms.

MATERIALS AND METHODS

The present study included the files of 238 consecutive patients with fractures of the facial bones who been treated with open reduction and osteosynthesis with the aid of 436 metallic plates. The average follow-up time was 6.9 months.

From the patient records, data including gender, age, fracture type, surgical approach, and plate location were recorded. Those patients who had undergone PR were identified and the indication for PR and number of plates removed was recorded. The PR delay (i.e., the time between plate insertion and PR) was calculated.

Fracture type

Each patient was assigned a fracture type from one of the following five groups: (1) exclusively mandibular fracture (one or more), (2) exclusively zygomatico-orbital fracture (i.e., tripoid zygomatic fracture), (3) exclusively orbital fracture (i.e., isolated orbital wall + rim fracture), (4) severe midfacial fracture (i.e., Le Fort I–III, naso-orbito-ethmoidal or multiple midfacial fracture), and (5)

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combined fractures (i.e., mandibular + midfacial fracture or panfacial fracture extending to all facial thirds).

Indication for PR

The indication for PR was selected from one of the following groups: (1) remaining growth, (2) objective reason (i.e., wound dehiscence, infection, screw loosening, and broken hardware), (3) subjective reason (i.e., cold sensitivity, palpability, and other type of subjective discomfort), (4) prophylactic, and (5) unknown reason (i.e., indication not recorded in the file).

Age groups

According to their age at the time of the injury, patients were classified as being children (12 years or less), teenagers (13−19 years) or adults (20 years or more). Adult patients were further classified into the age groups 20−29 years, 30−39 years, 40−49 years, 50−59 years, 60−69 years, and 70−79 years.

Surgical approach and plate location

For each plate inserted, the surgical approach was categorized as intraoral or extraoral (i.e., transcutaneous or transconjunctival). Additionally, one of the following six locations was assigned, with each group being defined according to both plate location and surgical approach: (1) mandibular intraoral (i.e., miniplates that had been inserted with an intraoral approach), (2) mandibular extraoral (i.e., reconstruction plates and condylar miniplates that had been inserted with an extraoral approach), (3) maxilla intraoral (i.e., miniplates inserted with an intraoral approach in the region of the zygomaticoalveolar buttress, paranasal buttress or maxillary sinus), (4) latero-orbital rim (i.e., miniplates that had been inserted with latero-orbital, blepharoplastic or coronal approaches), (5) infraorbital rim (i.e., mini- or microplates that had been inserted with transconjunctival or lower lid approaches), and (6) frontal bone (i.e., mini- or microplates that had been inserted with a coronal approach).

Data analysis

Bivariate associations between PR performed and indication for PR were evaluated according to gender, age group, fracture type, surgical approach and plate location. The statistical significance of the differences was evaluated with Chi-square tests. Because of the skewed distribution of the PR delay, the Kruskal−Wallis test was used to evaluate the statistical significance of PR delays between levels of indication for PR.

For the multiple logistic regression analysis, the performance of PR was used as the dichotomized dependent variable (yes/no). Age and number of inserted plates were used as continuous independent variables, and gender, fracture type, surgical approach, and plate location were used as categorical independent variables. For the regression analysis, fracture type was further categorized into (1) exclusively mandibular, (2) exclusively zygomatico-orbital, and (3) exclusively orbital, severe midfacial or combined. In addition, for the regression analyses, plate location was further categorized into (1) mandible intraoral or mandible extraoral, (2) latero-orbital rim or infraorbital rim, and (3) maxilla or frontal bone.

RESULTS

Descriptive statistics of the 238 patients are shown in Table 1. The great majority of patients (80.3%) were male. The largest age groups were 20−29 years (27.7%) and 30−39 years (23.1%). Only 10.5% of the patients were teenagers, and there were no children in this series. The most common fracture types were exclusively mandibular fracture (47.9%) and exclusively zygomatico-orbital fracture (36.1%). The great majority of patients (82.7%) had one or two osteosynthesis plates inserted. Fracture fixation was performed with exclusively intraoral approaches in 45.4% and with exclusively extraoral approaches in 40.8% of the patients, whereas combined intra- and extraoral approaches were used in 13.9%.

Table 2 shows the surgical approaches used and the locations of 436 plates. The slight majority of plates, 55.7%, had been inserted with an intraoral approach. The most common plate location was mandible intraoral (40.4%).

A total of 76 plates (17.4%) were removed from 48 patients (20.2%). Twenty-five of the 48 patients who underwent PR had received fracture fixation with one single plate, and subsequently had removal of only one plate. Thirteen patients had been treated with two plates, and in four of these patients only one symptomatic plate

Table 1 − Descriptive statistics of 238 patients

		n (%)
Gender	Males	191 (80.3)
	Females	47 (19.7)
Age (years)	Range	14.4−72.6
	Average	36.5
	<13	0 (0.0)
	13−19	25 (10.5)
	20−29	66 (27.7)
	30−39	55 (23.1)
	40−49	43 (18.1)
	50−59	37 (15.6)
	60−69	11 (4.6)
	70−79	1 (0.4)
Fracture type	Exclusively mandibular	114 (47.9)
	Exclusively zygomatico-orbital	86 (36.1)
	Severe midfacial	24 (10.1)
	Combined	9 (3.8)
	Exclusively orbital	5 (2.1)
Number of plates inserted	One plate	111 (46.6)
	Two plates	86 (36.1)
	Three plates	27 (11.3)
	Four plates	6 (2.5)
	Five plates	3 (1.3)
	Six plates	2 (0.8)
	Seven plates	3 (1.3)
Surgical approach	Intraoral only	108 (45.4)
	Extraoral only	97 (40.7)
	Combined intra- and extraoral	33 (13.9)

Table 2 − Surgical approaches used for and locations of 436 plates

		n (%)
Surgical approach	Intraoral	243 (55.7)
	Extraoral	193 (44.3)
Plate location	Mandible intraoral	176 (40.4)
	Latero-orbital rim	93 (21.3)
	Maxilla intraoral	67 (15.4)
	Infraorbital rim	44 (10.1)
	Mandible extraoral	34 (7.8)
	Frontal bone	22 (5.0)

Table 3 − Indications for PR in 48 patients

		Number of patients (%)
Objective reason		16 (33.3)
	Wound dehiscence/infection	10 (20.8)
	Screw loosening/broken hardware	5 (10.4)
	Re-operation	1 (2.1)
Unknown reason		15 (31.3)
Subjective reason		14 (29.2)
	Cold sensitivity	7 (14.6)
	Other discomfort	5 (10.4)
	Palpability	2 (4.1)
Growth		3 (6.3)

PR = Plate removal.

was removed. The remaining ten patients had received fracture fixation with three plates. In nine of them, all inserted plates were removed, whereas one patient underwent removal of two symptomatic plates.

The average PR delay was 8.8 months (range 29 days−2.7 years). The retention time was less than six months in 18 of the 48 patients (37.5%), between six months and one year in 17 patients (35.4%), between one and two years in 12 patients (25%), and more than two years in one patient (2.1%).

Table 3 shows the indications for PR. PR was performed for objective reasons in 33.3%, subjective reasons in 29.2%, and growth in 6.3% of the 48 patients. There were no entries in the patient files indicating that PR had been prophylactic, and the indication for PR remained unknown for 31.3%. The most common subjective reason for PR was cold sensitivity, whereas the most common objective reason was wound dehiscence or infection.

Table 4 shows how the indication for PR relates to gender, fracture type and PR delay. Women had PR for subjective reasons significantly more often than men (83.3% vs. 21.4%) ($p = 0.018$). PR was performed for subjective reasons significantly more often in patients who had sustained exclusively zygomatico-orbital fractures (78.6%) than in patients who had sustained mandibular fractures (6.7%) ($p = 0.002$). The average PR delay was significantly shorter for patients who had PR because of remaining growth (5.5 months) and objective reasons (5.5 months) than for patients who underwent PR for subjective reasons (9.8 months) ($p < 0.001$).

Table 5 shows the relationship between PR and gender, age, fracture type, surgical approach, and plate location in 238 patients. The Chi-square tests revealed no significant differences in PR rates between males and females, between age groups, or between fracture types. However, differences were observed when surgical approaches and plate locations were compared. Patients who underwent fixation with an intraoral approach had PR significantly more often (29.6%) than those who had fixation with an extraoral approach (13.4%) or a combined intra- and extraoral approach (9.1%) ($p = 0.004$). Moreover, patients who had plates inserted in the mandible by an intraoral approach had PR statistically significantly more often (33.0%) than patients who had plates inserted in the mandible from an extraoral approach or in any other location (0−15.8%) ($p = 0.006$).

Table 6 shows the relationship between PR and surgical approach and plate location for 436 plates. Plates that had been inserted with an intraoral approach were significantly more frequently removed (23.5%) than those inserted with an extraoral approach (9.8%) ($p < 0.001$). Plates that had been inserted in the mandible with an intraoral approach were removed more frequently (29.5%) than plates inserted in the mandible with an extraoral approach, in the maxilla, and in other locations through extraoral incisions (0−15.1%) ($p < 0.001$).

In the adjusted logistic regression analyses (Table 7), males had a 2.0-fold greater risk of PR compared with women. Moreover, exclusively mandibular fractures had a 2.0-fold and zygomatico-orbital fractures a 1.2-fold greater risk of PR compared with other fracture types. However, these results were not statistically significant. An extraoral surgical approach had a significantly higher risk of PR compared with operations in which combined extra- and intraoral approaches were used. Plates situated in the orbital rim (latero-orbitally or infraorbitally) had a significantly higher risk of PR than plates situated in the maxilla or the frontal bone.

DISCUSSION

Investigations in which the authors have calculated PR rates per plate show that removal rates vary widely, ranging from 3.7% to 27.2% (*Chaushu* et al., 2000; *Islamoglu* et al., 2002; *Murthy* and *Lehman*, 2005; *Nagase* et al., 2005; *Rallis* et al., 2006). The variability in PR rates per plate is most likely explained by the fact that some surgeons prefer to remove only those plates that cause objective or subjective problems, whereas others choose to remove all inserted plates in tandem with removal of one symptomatic plate. According to the results in the present study, surgeons in our unit follow the latter policy. Thus when PR was considered indicated, all plates that had been inserted in association with fracture repair were usually removed, explaining the relatively high PR rate per plate among our patients (17%). However, the PR rate per patient that we observed − 20.2% − is of the same magnitude as the rates that have been observed in previous studies (23.4−33.3%) (*Islamoglu* et al., 2002; *Nagase* et al., 2005; *Bakathir* et al., 2008).

Our assumption was that subjective discomfort, provoked by the cold Finnish climate, would be a significant indication for PR in our unit. This was based on findings of a study from Canada which revealed that subjective

Table 4 – Relationship between indication for PR and gender, fracture type and PR delay in 48 patients

		Objective (%)	Subjective (%)	Unknown (%)	Growth (%)
Gender	Males ($n = 42$)	15 (35.7)	9 (21.4)	15 (35.7)	3 (7.1)
	Females ($n = 6$)	1 (16.7)	5 (83.3)	0 (0.0)	0 (0.0)
	$p = 0.018$*				
Fracture type	Exclusively mandibular ($n = 30$)	12 (40.0)	2 (6.7)	13 (43.3)	3 (10.0)
	Exclusively zygomatico-orbital ($n = 14$)	2 (14.3)	11 (78.6)	1 (7.1)	0 (0.0)
	Severe midfacial ($n = 2$)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)
	Combined ($n = 2$)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)
	$p = 0.002$*				
PR delay	Range	29 days–1.5 years	3.9 months–2.7 years	6.1 months–2.0 years	3.2 months–9.2 months
	Average	5.5 months	9.8 months	1.0 years	5.5 months
	$p < 0.001$†				

PR = Plate removal.
* χ^2-test.
† Kruskal–Wallis test.

Table 5 – Relationship between PR and gender, age, fracture type, surgical approach and plate location in 238 patients

		PR performed (%)	PR not performed (%)
Gender	Male	42 (22.0)	149 (78.0)
	Female	6 (12.8)	41 (87.2)
	$p = 0.158$*		
Age group (years)	Mean (SD)	33.5 (12.9)	37.3 (13.7)
	13–19	7 (28.0)	18 (72.0)
	20–29	15 (22.7)	51 (77.3)
	30–39	11 (20.0)	44 (80.0)
	40–49	7 (16.3)	36 (83.7)
	50–59	7 (18.9)	30 (81.1)
	60–69	1 (9.1)	10 (90.9)
	70–79	0 (0.0)	1 (100)
	$p = 0.839$*		
Fracture type	Exclusively mandibular	30 (26.3)	84 (73.7)
	Exclusively zygomatico-orbital	14 (16.3)	72 (83.7)
	Severe midfacial	2 (8.3)	22 (91.7)
	Combined	2 (22.2)	7 (77.8)
	Exclusively orbital	0 (0.0)	5 (100.0)
	$p = 0.144$*		
Surgical approach	Intraoral only	32 (29.6)	76 (70.4)
	Extraoral only	13 (13.4)	84 (86.6)
	Combined intra- and extraoral	3 (9.1)	30 (90.9)
	$p = 0.004$*		
Plate location	Mandible intraoral	29 (33.0)	59 (67.0)
	Mandible extraoral	2 (6.9)	27 (93.1)
	Maxilla intraoral	3 (14.3)	18 (85.7)
	Latero-orbital rim	8 (15.7)	43 (84.3)
	Infraorbital rim	6 (15.8)	32 (84.2)
	Frontal bone	0 (0.0)	11 (100.0)
	$p = 0.006$*		

PR = Plate removal.
* χ^2-test.

Table 6 – Relationship between PR and surgical approach and plate location for 436 plates

		PR performed (%)	PR not performed (%)
Surgical approach	Intraoral	57 (23.5)	186 (76.5)
	Extraoral	19 (9.8)	174 (90.2)
	$p < 0.001$*		
Plate location	Mandible intraoral	52 (29.5)	124 (70.5)
	Mandible extraoral	1 (2.9)	33 (97.1)
	Maxilla intraoral	5 (7.5)	62 (93.5)
	Latero-orbital rim	14 (15.1)	79 (84.9)
	Infraorbital rim	4 (9.1)	40 (90.9)
	Frontal bone	0 (0.0)	22 (100)
	$p < 0.001$*		

PR = Plate removal.
* χ^2-test.

discomfort was the reason for PR in 72.4% of patients undergoing hardware removal (*Nagase* et al., 2005), and which mentioned the possible influence of the cold climate on this finding. The rate of patients undergoing PR for subjective reasons was notably lower in the present study (29.2%); however, it was clearly higher than the rates of 0% and 17.9% presented in studies conducted in Washington DC, USA (*Murthy* and *Lehman*, 2005) and Oman (*Bakathir* et al., 2008). We also observed that 14.6% of the patients who underwent PR stipulated that it was specifically because of cold intolerance, implying that the climate does have an influence on PR.

The study by *Nagase* et al. (2005) revealed that only 0–13% of hardware removals from the mandible were because of discomfort, whereas 14–54% of removals from the upper third of the face and 20–22% of removals from the latero-orbital and infraorbital area were related to subjective symptoms. We observed a similar tendency towards an increase in incidence of plate-related discomfort from inferior to superior along the facial skeleton. Subjective discomfort was the reason for PR in only 6.7% of the patients who had plates removed from the mandible but in as many as 78.5% of those who had hardware removed from the fixation points of zygomatico-orbital fractures. The association between plate location and PR because of subjective discomfort is related to the thin soft tissue cover in the midface and the upper third of the face, which causes greater awareness of plates inserted in these regions. The cold climate may additionally provoke symptoms in these areas.

During our file review we observed no entries indicating that PR had been prophylactic. However, the reason for PR was missing from the files of 31.3% patients. The average plate retention time in these patients was one year, the point when the last follow-up examination is

Table 7 − Logistic regression analysis for plate removal ($n = 238$)

Variable		Unadjusted OR (95% CI)	β	Adjusted OR (95% CI)	p
Gender	Females	1.0		1.0	
	Males	1.9 (0.8−4.9)	0.701	2.0 (0.8−5.2)	0.151
Age (as continuous)		0.98 (0.96−1.03)	−0.005	1.0 (0.97−1.02)	0.729
Fracture type	Exclusively mandibular	3.0 (0.99−9.3)	0.703	2.0 (0.3−13.2)	0.463
	Exclusively zygomatico-orbital	1.7 (0.5−5.4)	0.223	1.2 (0.3−5.0)	0.754
	Severe midfacial, exclusively orbital, combined	1.0		1.0	
Number of plates (as continuous)		0.9 (0.6−1.2)	−0.144	0.9 (0.5−1.4)	0.561
Plate location	Mandible intraoral/mandible extraoral	3.5 (1.0−12.3)	0.687	2.0 (0.2−15.9)	0.517
	Latero-orbital rim/infraorbital rim	1.8 (0.5−6.7)	2.343	19.4 (1.4 77.7)	0.022
	Maxilla intraoral/frontal bone	1.0		1.0	
Surgical approach	Intraoral only	1.5 (0.4−5.8)	0.129	1.1 (0.2−5.6)	0.873
	Extraoral only	4.3 (1.2−14.8)	2.192	9.0 (1.2−67.0)	0.034
	Combined intra- and extraoral	1.0		1.0	
Constant			−4.425		0.006

most often performed, indicating that these removals were to avoid later infection. Finnish consultant oral and maxillofacial surgeons are generally quite conservative with regard to routine PR after treatment of trauma; however, close to 50% perform routine titanium miniplate removal after treatment of mandibular angle fractures whenever the third molar has been left in situ during primary surgery (*Thorén* et al., 2008). The reason given was an increased risk of infections. The great majority of the patients in the present study who had PR for unknown reason (81.3%) had plates removed from the mandible, possibly reflecting the surgeons' concern over future infection-related complications. Indeed, previous studies have shown that whenever osteosynthesis material needs to be removed from the mandible, the reason is most often related to infections (*Islamoglu* et al., 2002; *Murthy* and *Lehman*, 2005; *Bakathir* et al., 2008). In addition, as observed in the present study, the lower jaw is particularly susceptible to complications and to a subsequent need for PR.

The development of mandibular osteosynthesis plates from large calibre, bicortical compression plates to monocortical miniplates has allowed increased intraoral access, a decrease in the necessity to expose bone, and an improved ease of handling of the plates (*Sauerbier* et al., 2008). Moreover, the development of specially shaped three-dimensional (3-D) miniplates has increased the treatment options in regions where the biomechanical requirements are particularly demanding, such as the subcondylar region (*Meyer* et al., 2007; *Meyer* et al., 2008). However, miniplates only cope with tensile stress and therefore require knowledge of the ideal lines of osteosynthesis. The repeated loading during mastication and the muscular forces acting on the mandible may overcome the rigidity of miniplates if they are not placed properly, subsequently leading to loosening or breaking of hardware, instability, non-union, or infection. The risk of complications is of particular significance in patients who have comminuted mandibular fractures (*Chaushu* et al., 2000) or atrophy of the lower jaw. Delayed treatment and pre-existing medical disorders (*Malanchuk* and *Kopchak*, 2007), smoking and chronic alcohol abuse (*Furr* et al., 2006), poor oral hygiene, and poor dental status further increase the risk of infection-related complications.

In the present study, PR was performed in 40.4% of patients who had undergone mandibular fixation with an intraoral approach but in only 2.9% of those who underwent treatment with an extraoral approach. This is a reminder of the fact that fixation with miniplates, despite its widespread use, is not always the principal treatment of choice in the mandible. In patients at risk, a reduction in the complication rate may be achieved with the use of more rigid fixation devices. The new angular stable mini-locking systems allow smaller access incisions and less soft tissue trauma than traditional reconstruction plates (*Gbara* et al. 2008a; *Gbara* et al. 2008b), yet providing a significantly higher stability than conventional miniplates.

CONCLUSIONS

There will always be a need for hardware removal in a portion of patients treated with metallic osteosynthesis devices. Approximately one in five patients eventually undergo PR because of hardware-related objective signs or subjective symptoms. As we assumed, subjective discomfort is a common reason for PR among Finnish patients, particularly in those facial regions that provide only thin soft tissue cover over the plate. The result suggests that the cold climate has an influence on the need for PR, and emphasizes that patients should be informed about the possible necessity of a second operation to remove hardware that causes discomfort. On the other hand, patients at particular risk of hardware removal because of wound dehiscence, infection, or loose or broken hardware had received mandibular fracture treatment with miniplates using an intraoral approach. This result underlines the fact that the use of rigid fixation devices should not be ignored, despite the widespread indications for the use of miniplates.

CONFLICT OF INTEREST

The authors of the paper do not have any conflicts of interest (financial or otherwise) relating to products, companies, or organizations.

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