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Original Article

Policy of fourteen maxillofacial divisions towards titanium plates removal after internal fixation of paediatric maxillofacial fractures: A World Oral Maxillofacial Trauma (WORMAT) project

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ABSTRACT

Introduction: The aim of this 11-year retrospective multicentric study is to evaluate the policy of 14 maxillofacial surgery divisions in terms of titanium plate removal from paediatric patients who had undergone open reduction and internal fixation (ORIF) to treat maxillofacial fractures.
Material and methods: Patients ≤ 16 years undergoing surgical treatment for fractures of middle and lower third of the face between January 2011 and December 2022, with a minimum follow-up of 6 months, were included. Age (group A: ≤ 6 years, B: 7–12 years, C: 13–16 years), sex, fracture location and type, surgical approach, number, and location of positioned and removed plates, timing and indications for removal were recorded.
Results: 191/383 (50 %) patients (median age, 10 years; M:F ratio 2.1:1) underwent removal of 319/708 (45 %) plates. Maxillary dentoalveolar process (91 %), angle/ramus (63 %) and mandibular body (61 %) had a significantly higher removal rate than other fracture sites ($p < 0.001$). A significant decreasing trend in removal with increasing age was observed, from 83 % in Group A to 24 % in Group C ($p < 0.001$). On the total of positioned plates, 11 % were removed for symptomatic reasons (5 % infections, 6 % discomfort/pain) and 34 % for other reasons (28 % scheduled removal).
Discussion: This multicentric study showed that plate removal was not performed routinely in the paediatric population. The incidence and causes of symptomatic plates removal were consistent with the literature, while the plate removal rate from asymptomatic patients was lower. A correlation was found between increasing age and a reduction in the frequency of plate removal procedures.

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1. Introduction

For over 40 years, open reduction and internal fixation (ORIF) with titanium plates has been the gold standard treatment for adult maxillofacial fractures, enabling effective three-dimensional stabilisation and promoting faster healing [1].

However, controversy persists regarding the fate of such devices once they have fulfilled their functions. Although titanium is highly biocompatible, certain studies suggest plate removal from all patients; others advocate removal only when this is clinically indicated [2–4].

There is even less literature on titanium plate removal from paediatric populations with facial trauma because of both the low incidence of fractures in children and the fact that ORIF is generally indicated only for displaced and comminuted fractures [5–9]. The risk that plates might compromise bone and dental development and/or potentially migrate over time, particularly in patients with a developing facial skeleton, might suggest, beyond absolute indications such as infection or pain, a need for routine plate removal in all patients [10,11]. However, a recent systematic review on the indications for and complications of titanium osteosynthesis in paediatric patients with maxillofacial trauma found that plate removal was not routinely performed, and confirmed the lack of relevant guidelines [9].

The aim of this retrospective multicentric study was to evaluate the policy of 14 maxillofacial surgery divisions participating in the World Oral Maxillofacial Trauma (WORMAT) project [12] in terms of titanium plate removal from paediatric populations who had undergone ORIF to treat maxillofacial fractures. The study also sought to determine the incidence and causes of plate removal and to identify associated factors.

2. Materials and methods

Fourteen centres participating in the WORMAT project received an Excel database to collect data on all patients aged ≤ 16 years undergoing surgical treatment for maxillofacial fractures under general anaesthesia between January 2011 and December 2022. A PDF file containing instructions on how to compile the database was also sent to each centre.

The participating centers were the following: Department of Oral and Maxillofacial Surgery, Paracelsus Medical University (Salzburg, Austria); Department of Oral and Maxillofacial Surgery, University Hospitals (Leuven, Belgium); Clinic for ENT and OMS, University Clinical Hospital (Mostar, Bosnia and Herzegovina); Department of Diagnosis and Surgery, Division of Oral and Maxillofacial Surgery, São Paulo State University, UNESP, Araraquara (São Paulo, Brazil); Department of Oral surgery, Faculty of Dental medicine, Medical University (Plovdiv, Bulgaria); Department of Maxillofacial Surgery, University Hospital Dubrava (Zagreb, Croatia); Department of Oral and Maxillofacial Surgery, Aligarh Muslim University (Aligarh, India); Oral and Maxillofacial Diseases Research Center, Mashhad University of Medical Sciences (Mashhad, Iran); Division of Maxillofacial Surgery, Città della Salute e della Scienza Hospital, University of Turin (Turin, Italy); Department of Oral and Maxillofacial Surgery, College of Medicine, University of Ibadan, (Ibadan, Nigeria); Clinic of Maxillofacial Surgery, School of dentistry, University of Belgrade (Belgrade, Serbia); Department of Maxillofacial and Oral Surgery, University Medical Centre (Ljubljana, Slovenia); Department of Oral and Maxillofacial Surgery, Muhimbili University of Health and Allied Sciences (Dar es Salaam, Tanzania); Department of Oral and Maxillofacial Surgery, University of Dundee (Dundee, United Kingdom).

Patients with maxillofacial fractures involving the lower- and middle-third of the face who were treated via ORIF using titanium plates and had a minimum follow-up of 6 months were included in the present study. Patients with upper-third facial fractures, those treated via closed reduction or open reduction without fracture fixation, or via fixation using resorbable plates, were excluded. Patients were divided into three age groups based on their stage of dental development: ≤6 years with deciduous dentition (Group A), 7–12 years with mixed dentition (Group B), and 13–16 years with permanent dentition (Group C).

The following data were collected: age; sex; number of plates placed; fracture location and type (non-displaced, displaced, comminuted); surgical approach (intraoral, extraoral or cervical, upper eyelid, supraorbital, lower eyelid, transconjunctival, coronal, endoscopic, or translesional); number and location of plates removed; time between plate insertion and removal (0–3 months, 3–6 months, 6–12 months, >12 months); and reasons for removal, divided by symptomatic and asymptomatic.

Symptomatic removal included removal because of infection, discomfort/pain, loosening, or exposure of the titanium implant. Asymptomatic removal included removal dictated by each centre's specific protocol and removal for aesthetic reasons or to facilitate post-trauma dental procedures.

This study was approved by the institutional committee of University Hospitals Leuven, Belgium (reference number S67588), and all procedures were conducted in accordance with the principles outlined in the 1964 Helsinki Declaration.

2.1. Statistical analysis

Statistical analysis was performed using SPSS software (version 28.0.1.0, IBM Corp., Armonk, NY, USA). Predictive factors and outcome variables were analysed using the Chi-square test and Chi square test for trend, as appropriate, with the Bonferroni correction applied for multiple comparisons. In detail, the association between the fracture site and the rate and cause of plate removal was analyzed with the Chi-square test with Bonferroni correction. The association between patient age and plate removal was analyzed with the Chi-square for trend. All statistical analyses were two-tailed, and the level of significance was set to $p < 0.05$.

3. Results

Over the 11-year period of this multicentric study, 383 patients aged ≤ 16 years underwent ORIF using a total of 708 titanium plates to treat fractures of the lower third (518 plates) and middle third (190 plates) of the facial skeleton; 11 patients had fractures in both regions. Of all patients, 86 % presented with at least one displaced or comminuted fracture that was treated via plate osteosynthesis. The most common surgical approach was intraoral for both lower- and middle-third fractures (71 % and 55 %, respectively). Other approaches used to treat lower-third fractures included extraoral (24 %), extraoral and intraoral (2 %), translesional (2 %), and endoscopic (1 %) methods. For patients with middle-third fractures, the following approaches were employed: translesional (11 %), coronal (7 %), lower eyelid (7 %), upper eyelid (7 %), transconjunctival (6 %), intra-extraoral (4 %), and supraorbital (3 %). All patients received perioperative antibiotic therapy. The mean follow-up was 21.6 months (range, 6–151 months).

A total of 191 of the 383 patients (50 %) (mean age, 10 years; standard deviation [SD], 4 years; 130 males and 61 females [ratio 2.1:1]) underwent subsequent removal of 319 plates (45 %), 88 from the middle third and 231 from the lower third of the face (Table 1).

As shown in Table 1, repaired fractures of the zygomaticomaxillary buttress and the symphysis/parasymphysis region were associated with the highest absolute number of removed plates (31 and 92 plates, respectively). Maxillary dentoalveolar fractures (91 %), angle/ramus fractures (63 %), and mandibular body fractures (61 %) were associated with significantly higher plate removal rates than other

Table 1
Proportion of plates removed by site of maxillofacial fracture and dentition stage.

		Dentition stage			Total
		Group A 0–6 years	Group B 7–12 years	Group C 13–16 years	
MIDDLE THIRD					
OMZc	Zygomaticomaxillary pillar	6/6	12/17	13/41	31/64 (48 %)
	Frontozygomatic suture	1/1	3/7	2/18	6/26 (23 %)
	Zygomaticotemporal suture	0/0	0/0	3/4	3/4 (75 %)
	Orbit inferior rim	2/2	5/7	1/11	8/20 (40 %)
Le Fort I or II fracture		6/7	14/14	1/25	21/46 (46 %)
NOE		1/2	2/6	1/6	4/14 (29 %)
Palatoalveolar		1/1	4/4	0/0	5/5 (100 %)
Dentoalveolar		2/2	4/4	4/5	10/11 (91 %)
Total		19/21 (90 %)	44/59 (75 %)	25/110 (23 %)	88/190 (46 %)
LOWER THIRD					
Condyle		6/17	6/37	4/60	16/114 (14 %)
Angle/ramus		10/10	24/28	23/52	57/90 (63 %)
Body		13/14	36/44	12/42	61/100 (61 %)
Symphysis/parasymphysis		21/21	40/57	31/131	92/209 (44 %)
Dentoalveolar		0/0	3/3	2/2	5/5 (100 %)
Total		50/62 (81 %)	109/169 (65 %)	72/287 (25 %)	231/518 (45 %)
MIDDLE AND LOWER THIRDS		69/83 (83 %)	153/228 (67 %)	97/397 (24 %)	319/708 (45 %)

Abbreviations: NOE: naso-orbitoethmoid complex; OMZc: Orbital maxillozygomatic complex.

fracture sites in the same facial third ($p < 0.001$, Chi-square test). By contrast, the frontozygomatic suture (23 %) and the condyle (14 %) exhibited the lowest incidences of plate removal, with the condylar data attaining statistical significance ($p < 0.001$, Chi-square test) (Table 1).

Analyzing the study sample by dentition stage, a significantly decreasing trend ($p < 0.001$, Chi-square test for trend) in terms of plate removal was observed with increasing age, from 83 % in Group A to 67 % and 24 % in Groups B and C, respectively, for both the middle and lower third (Table 1).

Of all plates placed, 34 % (240/708) were removed for other reasons unrelated to clinical symptoms, with scheduled removal being the main indication for removal from both the middle (53/190, 28 %) and lower third (145/518, 28 %) ($p > 0.05$, Chi-square test).

In 11 % of all cases (79/708), plates were removed for symptomatic reasons, more commonly from the lower third (61/518, 12 %) than the middle third (18/190, 9 %) ($p > 0.05$, Chi-square test). The incidence of removal because of infection was 12/190 (6 %) for the middle third and 27/518 (5 %) for the lower third; the removal rate because of discomfort/pain was 6/190 (3 %) and 34/518 (7 %) for the middle and lower thirds, respectively ($p > 0.05$, Chi-square test), as shown in Tables 2, 3, and 4.

In Group A, 39 of 52 patients (75 %) underwent removal of 69/83 (83 %) plates; 81 % of plates were removed from asymptomatic patients, with scheduled removal being the main reason (74 %), and 19 % were removed because of symptoms, principally pain (13 %) (Table 2). The removal timing was: < 3 months 12 %, 3–6 months 38 %, 6–12 months 28 %, and >12 months 22 %.

In Group B, 97 of 135 patients (72 %) underwent removal of 153/228 (67 %) plates; 65 % were removed from asymptomatic patients, with scheduled removal being the main reason (56 %), and 35 % were removed because of symptoms, principally pain (18 %) (Table 3). The removal timing was: < 3 months 7 %, 3–6 months 21 %, 6–12 months 30 %, and >12 months 42 %.

In Group C, 55 of 197 patients (28 %) underwent removal of 97/397 (24 %) plates; 87 % were removed from asymptomatic patients, with scheduled removal being the main reason (64 %), and 13 % were removed because of symptoms, principally infection (Table 4). The

Table 2
Number and indication of titanium plates removal by site of maxillofacial fracture in group A (0–6 years).

		Not symptomatic			Symptomatic			Total
		Scheduled	Aesthetical reasons	Dental procedures	Infection	Pain	Hardware exposition	
OMZc	Zygomaticomaxillary	2	3	0	0	1	0	6/6 (100 %)
	Frontozygomatic	1	0	0	0	0	0	1/1 (100 %)
	Zygomaticotemporal	0	0	0	0	0	0	0
	Orbit inferior rim	1	0	0	1	0	0	2/2 (100 %)
Le Fort		4	0	0	2	0	0	6/7 (86 %)
NOE		1	0	0	0	0	0	1/2 (50 %)
Palatoalveolar		1	0	0	0	0	0	1/1(100 %)
Dentoalveolar		2	0	0	0	0	0	2/2 (100 %)
Total		12	3	0	3	1	0	19/21 (90 %)
Condyle		4	0	0	0	2	0	6/17 (35.3 %)
Angle/ramus		8	0	0	0	2	0	10/10 (100 %)
Body		8	0	0	1	4	0	13/14 (93 %)
Symphysis/parasymphysis		19	2	0	0	0	0	21/21 (100 %)
Dentoalveolar		0	0	0	0	0	0	0
Total		39	2	0	1	8	0	50/62 (81 %)
Middle + lower third		51 (74 %)	5 (7 %)	–	4 (6 %)	9 (13 %)	–	69/83 (83 %)

Abbreviations: NOE: naso-orbitoethmoid complex; OMZc: Orbital maxillozygomatic complex.

Table 3
Number and indication of titanium plates removal by site of maxillofacial fracture in group B (7–12 years).

		Not symptomatic			Symptomatic			Total
		Scheduled	Aesthetical reasons	Dental procedures	Infection	Pain	Hardware exposition	
OMZc	Zygomaticomaxillary	7	0	1	1	3	0	12/17 (71 %)
	Frontozygomatic	3	0	0	0	0	0	3/7 (43 %)
	Zygomaticotemporal	0	0	0	0	0	0	0
	Orbit inferior rim	2	2	0	1	0	0	5/7 (72 %)
Le Fort		5	0	3	6	0	0	14/14 (100 %)
NOE		0	0	0	0	2	0	2/6 (33.3 %)
Palatoalveolar		4	0	0	0	0	0	4/4 (100 %)
Dentoalveolar		4	0	0	0	0	0	4/4 (100 %)
Total		25	2	4	8	5	0	44/59 (75 %)
Condyle		0	1	0	1	4	0	6/37 (16 %)
Angle/ramus		12	0	1	4	7	0	24/28 (86 %)
Body		21	2	2	5	6	0	36/44 (82 %)
Symphysis/parasymphysis		28	1	0	6	5	0	40/57 (70 %)
Dentoalveolar		0	0	1	2	0	0	3/3 (100 %)
Total		61	4	4	18	22	0	109/169 (65 %)
Middle + lower third		86 (56 %)	6 (4 %)	8 (5 %)	26 (17 %)	27 (18 %)	0	153/228 (67 %)

Table 4
Number and indication of titanium plates removal by site of maxillofacial fracture in group C (13–16 years).

		Not symptomatic			Symptomatic			Total
		Scheduled	Aesthetical reasons	Dental procedures	Infection	Pain	Hardware exposition	
OMZc	Zygomaticomaxillary	10	0	2	1	0	0	13/41 (32 %)
	Frontozygomatic	1	1	0	0	0	0	2/18 (11 %)
	Zygomaticotemporal	2	1	0	0	0	0	3/4 (75 %)
	Orbit inferior rim	0	1	0	0	0	0	1/11 (9 %)
Le Fort		1	0	0	0	0	0	1/25 (4 %)
NOE		0	1	0	0	0	0	1/6 (17 %)
Palatoalveolar		0	0	0	0	0	0	0
Dentoalveolar		2	0	2	0	0	0	4/5 (80 %)
Total		16	4	4	1	0	0	25/110 (23 %)
Condyle		2	0	0	1	1	0	4/60 (7 %)
Angle/ramus		13	0	3	4	3	0	23/52 (44 %)
Body		9	0	3	0	0	0	12/42 (29 %)
Symphysis/parasymphysis		20	0	8	3	0	0	31/131(24 %)
Dentoalveolar		2	0	0	0	0	0	2/2 (100 %)
Total		46	0	14	8	4	0	72/287 (25 %)
Middle + lower third		62 (64 %)	4 (4 %)	18 (19 %)	9 (9 %)	4 (4 %)	0	97/397 (24 %)

removal timing was < 3 months 7 %, 3–6 months 31 %, 6–12 months 46 %, and >12 months 16 %.

When considering fracture sites, scheduled removal was the most common reason for plate removal across all sites, along with aesthetic reasons for fractures of the lower orbital rim (Fig. 1). The exceptions were mandibular condyle and naso-orbito-ethmoid (NOE) fractures, for which pain was the primary cause of removal. Condylar fractures exhibited the lowest frequency of scheduled plate removal; with a statistically significant difference compared to other sites ($p < 0.001$, Chi-square test). The highest frequency of infections occurred in mandibular dentoalveolar (40 %), Le Fort I (17 %), lower orbital rim (10 %), and mandibular angle fractures (9 %), with statistical significance for the first two sites. Plates on the lower orbital rim were more frequently removed for aesthetic reasons than were plates in other sites ($p < 0.001$, Chi-square test).

4. Discussion

In summary, this first observational study retrospectively examined the policy of 14 maxillofacial surgery divisions worldwide in terms of titanium plate removal after maxillofacial trauma in children and adolescents. Among symptomatic plates, the incidence of removal, as well as the causes and sites, were consistent with previous reports in the literature, while the plate removal rate from asymptomatic patients was lower.

Since the introduction of ORIF using titanium plates to treat maxillofacial fractures, indications for plate removal in children and adolescents have remained controversial because of the lack of studies that have exclusively focused on this issue. Data can be inferred from articles on surgical treatment protocols and outcomes [5,8,10,13] or from case series [2,6,14,15] wherein the paediatric populations represent only small percentages of those enrolled, often lacking information on specific age groups. As reported in a recent review by Vercruysse et al. [9], there are no recognised guidelines on ORIF complications in paediatric patients with maxillofacial trauma; this review also highlighted that plate removal was not routinely performed.

On the one hand, some authors believe that all titanium plates should be removed within 2–3 months, thus after adequate bone union, to avoid possible growth restriction and plate migration [4,13,15–17]. On the other hand, others argue that plates should only be removed when complications such as infection, pain, plate exposure, or interference with eruption of permanent tooth buds arise [8,10,18], because, as stated in the systematic review of Olarte et al. [19], “there is insufficient evidence to prove that titanium hardware causes growth restriction when placed on the facial skeleton.”

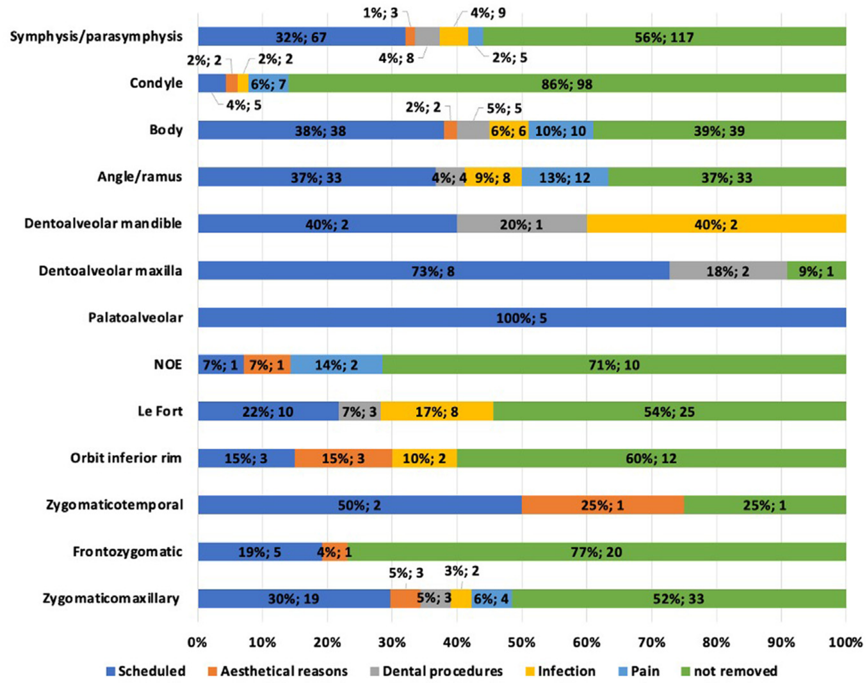

Fig. 1. Proportion and causes of titanium plate removal by maxillofacial fracture site.

When symptomatic, the percentage of plate removal in literature varies from 1 % [20] to 40 %; [21] our results are in line with those numbers. However, the available data primarily pertain to articles focusing on the treatment of mandibular fractures in specific sites, and the study cohorts are often small. The causes of plate removal reported in the present work, thus infection and pain, are in line with the reports of Lee et al. [22] on ORIF to treat mandibular fractures, and of Luck et al. [23] on ORIF to treat maxillozygomatic fractures. Additionally, the authors of the present study observed that the complication rate was slightly higher when plates were placed in the lower than the middle third of the facial skeleton (12% vs. 9 %), although statistical significance was not attained, as previously reported in the adult population [1,3,6,15,24]. Several authors have suggested that the difference arises because plates in the mandible are subjected to greater functional loads than plates in other sites and are prone to repeated trauma caused by mastication and dentures, particularly in the body, angle and dentoalveolar regions [3,14,24,25], consistent with the observations in this study. By contrast, a recent meta-analysis and systematic review concluded that plates in the upper jaws were "likely to be without complications due to better vascularization and the least deposition of food debris and saliva." [4]

In terms of plates of asymptomatic patients, the Strasbourg osteosynthesis research group in 1991 recommended their removal, provided that removal did not pose excessive risks to the patient [26]. In 2005, Bos [11] suggested plate removal from children not to prevent a growth disturbance, but rather because of potential passive translocation by drift phenomena. Indeed, in a study on growing patients with craniosynostosis, it has been reported that bone growth may lead to inclusion or even to intracranial displacement of plates and screws, in particular those placed in the temporal region, with no apparent adverse sequalae on the underlying dura and brain [27]. The authors speculated that hardware translocation may be a consequence of the normal remodelling of the growing calvarium and the typical compensatory growth pattern of patients with craniosynostosis, as also suggested by Munro et al. [28]. However, to the best of our knowledge, this has never been described in the maxillofacial region. By contrast, Siy et al. [10] recommended early plate removal from the middle and lower thirds of the face, before bone could cover the implant, rendering implant visualisation difficult.

This observational study found that, in all centres of the WORMAT project, plate removal was not performed routinely, as in the adult population. The percentage of asymptomatic plate removals was 34 % (two-thirds of which were scheduled), thus significantly lower than the 90 % reported in the recent systematic review by Pontell et al. [29] However, in Group A patients, the percentage of removed plates was 90 % and 81 % of those positioned in the middle and lower facial thirds, respectively. This underscores the general policy across all centers to remove titanium devices in all patients with a developing skeleton. Conversely, in group C patients, thus at the end of skeletal growth, the percentage of asymptomatic plate removal (21 %), most of which were scheduled, was comparable to those for adults, ranging from 2 % [30] to 56 % [3].

The limitations of this study were the retrospective design and the relatively short follow-up. Although we reviewed data collected over 11 years, the long-term outcomes in terms of the development of tooth germs and the facial skeleton after plate osteosynthesis remain unknown.

In summary, given the limited data on titanium plate removal, particularly in asymptomatic cases, we suggest that future, multicentre prospective studies with large sample sizes and long follow-up are required to establish clear guidelines for plate removal in the paediatric population.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Giulia Cremona: Writing – review & editing, Writing – original draft. **Serena Paione:** Writing – review & editing, Writing – original draft. **Fabio Roccia:** Writing – review & editing, Writing – original draft, Supervision, Data curation, Conceptualization. **Sahand**

Samieirad: Validation, Data curation. **Marko Lazíc:** Validation, Data curation. **Vitomir S. Konstantinovic:** Validation, Data curation. **Euan Rae:** Validation, Data curation. **Sean Laverick:** Validation, Data curation. **Aleš Vesnaver:** Validation, Data curation. **Anže Birk:** Validation, Data curation. **Luis Fernando de Oliveira Gorla:** Validation, Data curation. **Valfrido Antonio Pereira-Filho:** Validation, Data curation. **Emil Dediol:** Validation, Data curation. **Boris Kos:** Validation, Data curation. **Petia Pechalova:** Validation, Data curation. **Angel Sapundzhiev:** Validation, Data curation. **Kathia Dubron:** Validation, Data curation. **Constantinus Politis:** Validation, Data curation. **Emanuele Zavattero:** Data curation. **Gian Battista Bottini:** Validation, Data curation. **Maximilian Goetzinger:** Validation, Data curation. **Anamaria Sivrić:** Validation, Data curation. **Mario Kordić:** Validation, Data curation. **Sajjad Abdur Rahman:** Validation, Data curation. **Tabishur Rahman:** Validation, Data curation. **Karpal Singh Sohal:** Validation, Data curation. **Timothy Aladelusi:** Validation, Data curation. **Federica Sobrero:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization.

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References

[1] Ehrenfeld M, Prein J. Principles of craniomaxillofacial trauma care. In: Ehrenfeld M, Manson PN, Prein J, editors. Principles of Internal Fixation of the Craniomaxillofacial Skeleton. Trauma and Orthognathic Surgery Stuttgart: Georg Thieme Verlag KG; 2012. p. 137–79.
[2] Pan Z, Patil PM. Titanium osteosynthesis hardware in maxillofacial trauma surgery: to remove or remain? A retrospective study. Eur J Trauma Emerg Surg 2014;40:587–91. doi: 10.1007/s00068-013-0348-5.
[3] Sukegawa S, Masui M, Sukegawa-Takahashi Y, et al. Maxillofacial trauma surgery patients with titanium osteosynthesis miniplates: remove or not? J Craniofac Surg 2020;31:1338–42. doi: 10.1097/SCS.0000000000006352.
[4] Piombino P, Sani L, Sandu G, et al. Titanium internal fixator removal in maxillofacial surgery: is it necessary? A systematic review and meta-analysis. J Craniofac Surg 2023;34:145–52. doi: 10.1097/SCS.0000000000009006.
[5] Zimmermann CE, Troulis MJ, Kaban LB. Pediatric facial fractures: recent advances in prevention, diagnosis and management. Int J Oral Maxillofac Surg 2006;35:2–13. doi: 10.1016/j.ijom.2005.09.014.
[6] O'Connell J, Murphy C, Ikeagwuani O, Adley C, Kearns G. The fate of titanium miniplates and screws used in maxillofacial surgery: a 10 year retrospective study. Int J Oral Maxillofac Surg 2009;38:731–5. doi: 10.1016/j.ijom.2009.02.016.
[7] Iatrou I, Theologie-Lygidakis N, Tzerbos F. Surgical protocols and outcome for the treatment of maxillofacial fractures in children: 9 years' experience. J Cranio-Maxillofacial Surg 2010;38:511–6. doi: 10.1016/j.jcms.2010.02.008.
[8] Allred LJ, Crantford JC, Reynolds MF, David LR. Analysis of pediatric maxillofacial fractures requiring operative treatment: characteristics, management, and outcomes. J Craniofac Surg 2015;26:2368–74. doi: 10.1097/SCS.0000000000002087.
[9] Vercruysse M, Willaert R, Goormans F, Coropciuc R, Politis C. Indications and complications regarding titanium osteosynthesis in pediatric maxillofacial trauma: a scoping review and critical appraisal. J Stomatol Oral Maxillofac Surg 2023;124:101284. doi: 10.1016/j.jormas.2022.09.005.
[10] Siy RW, Brown RH, Koshy JC, Stal S, Hollier LH. General management considerations in pediatric facial fractures. J Craniofac Surg 2011;22:1190–5. doi: 10.1097/SCS.0b013e31821c0cf9.
[11] Bos RRM. Treatment of pediatric facial fractures: the case for metallic fixation. J Oral Maxillofac Surg 2005;63:382–4. doi: 10.1016/j.joms.2004.11.010.
[12] Roccia F, Iocca O, Sobrero F, et al. World Oral and Maxillofacial Trauma (WORMAT) project: a multicenter prospective analysis of epidemiology and patterns of maxillofacial trauma around the world. J Stomatol Oral Maxillofac Surg 2022;123:e849–57. doi: 10.1016/j.jormas.2022.05.004.
[13] Maqusi S, Morris DE, Patel PK, Dolezal RF, Cohen MN. Complications of pediatric facial fractures. J Craniofac Surg 2012;23:1023–7. doi: 10.1097/SCS.0b013e31824e7106.
[14] Thorén H, Snäll J, Hallermann W, Kormi E, Törnwall J. Policy of routine titanium miniplate removal after maxillofacial trauma. J Oral Maxillofac Surg 2008;66:1901–4. doi: 10.1016/j.joms.2008.03.009.
[15] Bakathir AA, Margasahayam MV, Al-Ismaily MI. Removal of bone plates in patients with maxillofacial trauma: a retrospective study. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology 2008;105:32–7. doi: 10.1016/j.tripleo.2008.01.006.
[16] Iatrou I, Theologie-Lygidakis N, Tzermpos F, Kamperos G. Internal fixation of mandibular angle fractures using one miniplate in Greek children: a 5-year retrospective study. J Cranio-Maxillofacial Surg 2015;43:53–6. doi: 10.1016/j.jcms.2014.10.009.
[17] Huang W, Hu S, Wang C, Xiao J. Analysis of pediatric maxillofacial fractures: a 10-year retrospective study. J Craniofac Surg 2023;34:448–53. doi: 10.1097/SCS.0000000000008846.
[18] Sobrero F, Roccia F, Galetta G, Strada C, Gerbino G. Pediatric mandibular fractures: surgical management and outcomes in the deciduous, mixed and permanent dentitions. Dent Traumatol 2023;39:233–9. doi: 10.1111/edt.12814.
[19] Fernández-Olarte H, Gómez-Delgado A, López-Dávila D, Rangel-Perdomo R, Lafaurie GI, Chambrone L. Is the mandibular growth affected by internal rigid fixation?: a systematic review. J Maxillofac Oral Surg 2017;16:277–83. doi: 10.1007/s12663-016-0968-5.
[20] Zhou W, An J, He Y, Zhang Y. Analysis of pediatric maxillofacial trauma in North China: epidemiology, pattern, and management. Injury 2020;51:1561–7. doi: 10.1016/j.injury.2020.04.053.
[21] Lopez J, Reategui A, Yesantharao PS, et al. Open reduction, internal fixation, or maxillo-mandibular fixation for isolated, unilateral, tooth-bearing, mandibular body fractures in children. J Craniofac Surg 2021;32:73–7. doi: 10.1097/SCS.0000000000006990.
[22] Lee CC, Tannyhill RJ, Peacock ZS. What factors are associated with open treatment of pediatric mandibular fractures? J Oral Maxillofac Surg 2021;79:1292–301. doi: 10.1016/j.joms.2020.12.022.
[23] Luck JD, Lopez J, Faateh M, et al. Pediatric zygomaticomaxillary complex fracture repair: location and number of fixation sites in growing children. Plast Reconstr Surg 2018;142:51E–60E. doi: 10.1097/PRS.0000000000004487.
[24] Murthy AS, Lehman JA. Symptomatic plate removal in maxillofacial trauma: a review of 76 cases. Ann Plast Surg 2005;55:603–7. doi: 10.1097/01.sap.0000183802.38116.37.
[25] Chaushu G, Manor Y, Shoshani Y, Taicher S. Risk factors contributing to symptomatic plate removal in maxillofacial trauma patients. Plast Reconstr Surg 2000;105:521–5. doi: 10.1097/00006534-200002000-00006.
[26] Strasbourg Osteosynthesis Group. Consensus Statement. In: Proceedings of the 3rd SORG Meeting; 1991. 14–16 November.
[27] Goldberg DS, Bartlett SP, Yu JC, Hunter JV, Whitaker LA. Critical review of microfixation in pediatric craniofacial surgery. J Craniofac Surg 1995;6:301–7. doi: 10.1097/00001665-199507000-00008.
[28] Munro IR, Fearon JA, Bruce DA. Complications of rigid fixation in infants and small children. In: Paper presented at the Fifth International Congress of the International Society of Craniofacial Surgery; 1993.
[29] Pontell ME, Niklinska EB, Braun SA, Jaeger N, Kelly KJ, Golinko MS. Resorbable versus titanium rigid fixation for pediatric mandibular fractures: a systematic review, institutional experience and comparative analysis. Craniomaxillofac Trauma Reconstr 2022;15:189–200. doi: 10.1177/19433875211022573.
[30] Yu Y, Liu W, Chen J, Quan L, Zheng X, Liu L. No need to routinely remove titanium implants for maxillofacial fractures. J Oral Maxillofac Surg 2019;77:783–8. doi: 10.1016/j.joms.2018.10.022.