Received: 19 February 2024 | Revised: 26 May 2024 | Accepted: 27 May 2024

DOI: 10.1111/edt.12976

Dental Traumatology WILEY

ORIGINAL ARTICLE

Open reduction and internal fixation of paediatric maxillozygomatic complex fractures: An 11-year multicentric retrospective study

Fabio Roccia[1] | Federica Sobrero[1] | Carlo Strada[1] | Gian Battista Bottini[2] | Maximilian Goetzinger[2] | Sahand Samieirad[3] | Aleš Vesnaver[4] | Anže Birk[4] | Luis Fernando de Oliveira Gorla[5] | Valfrido Antonio Pereira-Filho[5] | Emil Dediol[6] | Boris Kos[6] | Petia Pechalova[7] | Angel Sapundzhiev[7] | Marko Lazíc[8] | Vitomir S. Konstantinovic[8] | Kathia Dubron[9] | Constantinus Politis[9] | Paolo Garzino Demo[1] | Anamaria Sivrić[10] | Mario Kordić[10] | Sajjad Abdur Rahman[11] | Tabishur Rahman[11] | Karpal Singh Sohal[12] | Timothy Aladelusi[13] | Euan Rae[14] | Sean Laverick[14]

[1]Division of Maxillofacial Surgery, Città della Salute e della Scienza Hospital, University of Turin, Turin, Italy

[2]Department of Oral and Maxillofacial Surgery, Paracelsus Medical University, Salzburg, Austria

[3]Oral and Maxillofacial Diseases Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

[4]Department of Maxillofacial and Oral Surgery, University Medical Centre, Ljubljana, Slovenia

[5]Division of Oral and Maxillofacial Surgery, Department of Diagnosis and Surgery, São Paulo State University, UNESP, São Paulo, Brazil

[6]Department of Maxillofacial Surgery, University Hospital Dubrava, Zagreb, Croatia

[7]Department of Oral Surgery, Faculty of Dental Medicine, Medical University of Plovdiv, Plovdiv, Bulgaria

[8]Clinic of Maxillofacial Surgery, School of Dentistry, University of Belgrade, Belgrade, Serbia

[9]Department of Oral and Maxillofacial Surgery, University Hospitals Leuven, Leuven, Belgium

[10]Clinic for ENT and OMS, University Clinical Hospital, Mostar, Bosnia and Herzegovina

[11]Department of Oral and Maxillofacial Surgery, Aligarh Muslim University, Aligarh, India

[12]Department of Oral and Maxillofacial Surgery, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania

[13]Department of Oral and Maxillofacial Surgery, College of Medicine, University of Ibadan, Ibadan, Nigeria

[14]Department of Oral and Maxillofacial Surgery, University of Dundee, Dundee, UK

Correspondence
Federica Sobrero, Division of Maxillofacial Surgery, Department of Surgical Sciences, Città della Salute e delle Scienze Hospital, University of Turin, Via Genova 3, 10131, Turin, Italy.
Email: federica.sobrero@unito.it

Abstract

Background/aim: Paediatric maxillozygomatic complex (MZC) fractures are uncommon, and there is a scarcity of data regarding their surgical treatment. The aim of this study was to analyse choices and outcomes of open reduction and internal fixation (ORIF) for MZC fractures among 14 maxillofacial centers around the world.

Materials and Methods: This multicentric retrospective observational study included patients ≤16 years of age with quadripod MZC fractures treated with ORIF from January 2011 and December 2022. The following data were collected: age, gender, dentition stage (deciduous, mixed, and permanent), cause of injury, type of fracture, surgical

approach, site of osteosynthesis (infraorbital rim, zygomaticomaxillary buttress, frontozygomatic, and zygomaticotemporal sutures), material (titanium or resorbable) and number of plates used, and outcome. The minimum follow-up was 6 months. Statistical analyses were performed with Fisher's exact test or chi-squared test, as appropriate.

Results: Sixty-four patients (mean age, 12.3 years) with quadripod MZC fractures were included. Seventy-two percent of patients received a single-point fixation. The zygomaticomaxillary buttress was the most common site for fixation, both in single-point and two-point fixation schemes, especially in combination with the frontozygomatic suture. Increasing age was associated with a higher rate of plate removal ($p < .001$). Postoperative complications included 5 (7.8%) cases of wound infections, 2 (3.1%) infraorbital paraesthesia, 1 (1.6%) ectropion. Residual facial asymmetry was found in 5 (7.8%) patients and was not associated with the type of fixation ($p > .05$).

Conclusions: This study highlights the possibility of using ORIF, even with a single point of fixation, for the treatment of displaced quadripod MZC fractures in the paediatric population. The zygomaticomaxillary buttress was the preferred site of fixation and allowed for adequate stabilization with no external scars and a low risk of tooth damage. Future prospective studies with long-term follow-up are needed to establish definitive surgical protocols and clarify the surgical decision-making.

KEYWORDS
adolescent, child, fracture fixation, maxillary fractures, zygomatic fractures

1 | INTRODUCTION

Paediatric facial fractures are uncommon, especially in children aged <16 years, accounting for 15% of all maxillofacial injuries.[1–3] This relatively low incidence is primarily due to the fact that children under parental supervision are less exposed to trauma, have a relatively small facial surface, have paranasal sinuses that are not yet pneumatised, and are protected from facial fracture by the presence of significant subcutaneous fat and greater bone elasticity.[4–6] Paediatric maxillo-mandibular fractures are rarely treated surgically. The developing bone structure, the occlusal instability of mixed dentition, the presence of tooth germs, and potential difficulties in patient acceptance and cooperation make nonsurgical conservative approaches preferable, while plate and screw fixation are reserved for displaced or comminuted fractures.[5,7–9]

Consequently, most previous studies have focused on the epidemiology and management strategies of paediatric trauma, while studies on surgical treatment are scarce and based on small populations, except in the case of mandibular fractures, and definitive surgical protocols are missing.[4,10–16] This report presents the combined experience of 14 Maxillofacial Surgery divisions participating in the WORMAT (World Oral Maxillofacial Trauma) project[3] on open reduction and internal fixation (ORIF) for paediatric fractures of the maxillozygomatic complex (MZC). The aim was to evaluate the management strategies, particularly the choices of reduction and internal fixation, and outcomes, in a retrospective review spanning 11 years.

2 | MATERIALS AND METHODS

Fourteen centres participating in the WORMAT project received an Excel database to collect data from patients ≤16 years of age who had been operated on under general anaesthesia between January 2011 and December 2022 for fractures of the maxillofacial region. Additionally, a PDF file with instructions for database compilation was provided. The participating centers were the following: Department (Dpt.) of Oral and Maxillofacial Surgery, Paracelsus Medical University (Salzburg, Austria); Dpt. of Oral and Maxillofacial Surgery, University Hospitals (Leuven, Belgium); Clinic for ENT and OMS, University Clinical Hospital (Mostar, Bosnia and Herzegovina); Dpt. of Diagnosis and Surgery, Division of Oral and Maxillofacial Surgery, São Paulo State University, UNESP, Araraquara (São Paulo, Brazil); Dpt. of Oral surgery, Faculty of Dental medicine, Medical University (Plovdiv, Bulgaria); Dpt. of Maxillofacial Surgery, University Hospital Dubrava (Zagreb, Croatia); Dpt. 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); Dpt. 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); Dpt. of Maxillofacial and Oral Surgery, University Medical Centre (Ljubljana, Slovenia); Dpt. of Oral and Maxillofacial Surgery,

TABLE 1 Number of maxillozygomatic complex sites undergoing internal fixation among WORMAT project centres.

	Zygomaticomaxillary buttress, *n* (%)	Fronto-zygomatic suture, *n* (%)	Infraorbital rim, *n* (%)	Temporozygomatic buttress, *n* (%)
Austria	9 (69.2)	2 (15.3)	2 (15.3)	0
Belgium	4 (66.6)	1 (16.7)	1 (16.7)	0
Brazil	6 (46.1)	5 (38.5)	2 (15.4)	0
Croatia	5 (62.5)	3 (37.5)	0	0
Iran	8 (72.7)	0	3 (27.3)	0
Italy	10 (55.6)	2 (11.1)	6 (33.3)	0
Serbia	0	0	1 (100)	0
Slovenia	4 (36.4)	6 (54.5)	1 (9.1)	0
UK	3 (60.0)	2 (40.0)	0	0
Total	49 (57.0)	21 (24.4)	16 (18.6)	0

Muhimbili University of Health and Allied Sciences (Dar es Salaam, Tanzania); Dpt. of Oral and Maxillofacial Surgery, University of Dundee (Dundee, United Kingdom).

Patients diagnosed with a quadripod MZC fracture type B according to Zingg classification[17] through a preoperative computed tomography (CT) scan, with no history of previous facial trauma, were included. Patients with fractures type A1, A2, A3 and C according to Zingg classification,[17] or with fractures treated by closed reduction were excluded. In addition, patients with incomplete clinical or radiological records were excluded.

The patients were divided into three groups by stage of dentition: infants and preschool children with deciduous dentition (≤6 years; Group A), school-age children with mixed dentition (7–12 years; Group B) and adolescents with permanent dentition (13–16 years; Group C).[18]

The following data were collected: age, sex, cause of injury (road traffic accident [RTA], fall, assault, sport- or work-related injury, other), type of fracture (nondisplaced, displaced, comminuted), associated facial fractures, time of surgery (<24 h, 24–72 h, >72 h), surgical approach (intraoral, extraoral [upper eyelid, supraorbital eyebrow, inferior eyelid, transconjunctival, coronal], translesional), site of osteosynthesis (infraorbital rim, zygomaticomaxillary buttress, frontozygomatic, and zygomaticotemporal sutures), material (titanium or resorbable), number of plates used, and outcome. A point of fixation was defined as a fracture site osteosynthesized with one or more plates and screws. The osteosynthesis schemes were classified as one-point, two-point, three-point or four-point fixation according to the number of fixation points (one, two, three or four, respectively).

The following outcomes were recorded after a minimum follow-up of 6 months: plate removal and reason, dental developmental abnormalities (any alteration in the timing or pattern of dental eruption), tooth root damage, surgical wound infection/dehiscence, hardware loosening/failure, post-traumatic sensory changes in the infraorbital nerve area, and notable facial asymmetry. Postoperative infection was defined as purulent discharge from the surgical site, oedema or induration with erythema or hardware exposure with pus discharge. Notable facial asymmetry was defined as the presence of any difference in morphology between the two sides of the face in areas affected by the trauma that were not present before the injury, as reported by the patient or a parent and confirmed by the surgeon.

This study received approval from the institutional committee (reference number S67588), and all procedures were performed in accordance with the 1964 Helsinki Declaration. Informed consent was obtained as required.

Statistical analyses were performed using SPSS software (version 28.0.1.0; IBM Corp., Armonk, NY, USA). The predictors and outcomes were analysed using Fisher's exact test and chi-squared test, as appropriate. All statistical analyses were two-tailed. The significance level was set at $p < .05$.

3 | RESULTS

During the enrolment period, 740 children or adolescents ≤16 years of age underwent surgery under general anaesthesia for maxillofacial fractures. Sixty-four patients (mean age, 12.3 years; standard deviation [SD], 3.8 years) from 9 out of 14 centres met the inclusion criteria. Based on their age, 7 patients (4 males and 3 females) were assigned to Group A, 21 (12 males and 9 females) to Group B, and 36 (30 males and 6 females) to Group C.

The cause of MZC fracture was RTA in 25 patients, sports-related injuries in 18 patients, falls in 13 patients, assaults in 4 patients and other causes in 4 patients. Of the 64 patients, 62 (97%) had displaced type B MZC fracture, the remaining 2 had nondisplaced type B fractures.

Six patients had associated fractures in the lower third, and two in the upper third of the face. Among patients with fractures in the middle third, 23 had orbital fractures, including 19 involving the floor (15 treated surgically), 3 involving the medial wall (2 treated surgically) and 1 involving the roof (treated surgically); 4 patients had fractures of the nasal bones (3 treated surgically).

Surgery was performed in 12 patients within 24 h, in 25 patients between 24 and 72 h, and in the remaining 27 after 72 h.

A total of 99 plates were used to fix 86 fracture sites (13 sites being fixed with more than one plate). Ninety-six out of 99 of the plates were made of titanium. Only two centres used resorbable plates (for one group A patient and two group B patients).

The most commonly used site for fixation was the zygomaticomaxillary buttress, exposed through an intraoral approach (49 patients), followed by the frontozygomatic suture in 21 patients, exposed through an upper eyelid (8 patients) or through a translesional (8 patients) or supraorbital eyebrow approach (5 patients). In the remaining 16 patients who underwent fixation of the lower orbital rim, the approach was via the lower eyelid in 10 patients and transconjunctival in 6 patients (Table 1).

In 72% of the patients, internal fixation involved a single point, including all patients in Group A. Three-point fixation was used in only four patients (6%), all from Group C (Table 2). With increasing age, there was a trend towards an increase in the number of fixation points, although not statistically significant ($p > .05$, Fisher's exact test).

The zygomaticomaxillary buttress was the most frequently used site in both one-point (33 of 46) and two-point (12 of 14) fixations, especially in combination with the frontozygomatic suture (Table 3).

Thirty-seven of the 96 titanium plates (39%) were removed, all within 1 year of the surgical intervention except in 5 patients from group B. Plate removal was scheduled in over half of the patients (22 out of 37; 59%) (Table 4). Unplanned plate removal was necessitated by aesthetic reasons (e.g., palpability through the skin or mucosa, visibility under the skin) (14%), pain (11%) or local infections (8%). Three plates at the zygomaticomaxillary buttress were removed to facilitate subsequent dental procedures. Osteosynthesis devices placed on the zygomaticomaxillary buttress were removed more frequently than those placed on other sites (45% vs. 38% and 23% at the level of the lower orbital rim and frontozygomatic suture, respectively), but the differences were not statistically significant ($p > .05$, chi-squared test). A significant decreasing trend in plate removal with decreasing age was determined, from 100% in Group A patients to 63% in Group B patients and 17% in Group C patients ($p < 0.001$, chi-squared for trend).

The average follow-up duration was 18.8 months. Postoperative complications included infections of the surgical wound in 5 (7.8%) patients (4 intraoral and 1 lower eyelid), postoperative infraorbital paraesthesia in 2 (3.1%) patients, and ectropion resulting from a lower lid approach in 1 (1.6%) patient.

Residual notable facial asymmetry occurred in 5 (7.8%) patients: three patients in Group B and one in Group C developed slight asymmetries in the middle third of the face following a one-point fixation in three patients and two-point fixation in one patient. In addition, a 16-year-old boy with a MZC fracture treated with three-point fixation had residual hypoglobus and diplopia. No association was found between residual visual asymmetry and the type of fixation ($p > .05$, Fisher's exact test).

TABLE 2 Number of internal fixation points according to age group and country.

Group age (years)	No. fixation points			Total patients
	One point	Two points	Three points	
Austria				
≤6	1	0	0	1
7–12	2	0	0	2
13–16	6	2	0	8
Belgium				
≤6	1	0	0	1
7–12	0	0	0	0
13–16	2	0	1	3
Brazil				
≤6	2[a]	0	0	2
7–12	0	0	0	0
13–16	3	1	2	6
Croatia				
≤6	0	0	0	0
7–12	1	1	0	2
13–16	1	2	0	3
Iran				
≤6	3	0	0	3
7–12	8[b]	0	0	8
13–16	0	0	0	0
Italy				
≤6	0	0	0	0
7–12	2	3	0	5
13–16	3	2	1	6
Serbia				
≤6	0	0	0	0
7–12	0	0	0	0
13–16	1	0	0	1
Slovenia				
≤6	0	0	0	0
7–12	2	2	0	4
13–16	3	1	0	4
UK				
≤6	0	0	0	0
7–12	0	0	0	0
13–16	5	0	0	5
All patients				
≤6	7 (100%)	0	0	7
7–12	15 (71%)	6 (29%)	0	21
13–16	24 (67%)	8 (22%)	4 (11%)	36
Total	46 (72%)	14 (22%)	4 (6%)	64

[a]One resorbable plate.

[b]Two resorbable plates.

TABLE 3 Scheme of internal fixation of the MZC sites by age group and country.

	Sites/No. patients							
Group age (years)	Mz	Fz	Or	Mz + Fz	Mz + Or	Fz + Or	Mz + Fz + Or	Total patients
Austria								
≤6			1					1
7–12	1	1						2
13–16	6			1	1			8
Belgium								
≤6	1							1
7–12								0
13–16	2						1	3
Brazil								
≤6		2						2
7–12								0
13–16	3			1			2	6
Croatia								
≤6								0
7–12	1			1				2
13–16	1			2				3
Iran								
≤6	3							3
7–12	5*		3*					8
13–16								0
Italy								
≤6								0
7–12	2				2	1		5
13–16	3				2		1	6
Serbia								
≤6								0
7–12								0
13–16			1					1
Slovenia								
≤6								0
7–12		2		1		1		4
13–16	2	1		1				4
UK								
≤6								0
7–12								0
13–16	3	2						5
All patients								
≤6	4	2	1	0	0	0	0	7
7–12	9	3	3	2	2	2	0	21
13–16	20	3	1	5	3	0	4	36
Total	33 (51.6%)	8 (12.5%)	5 (7.8%)	7 (10.9%)	5 (7.8%)	2 (3.1%)	4 (6.3%)	64

Abbreviations: Fz: fronto-zygomatic suture; Mz: zygomaticomaxillary buttress; Or: inferior orbital rim.

*One resorbable plate.

TABLE 4 Causes of titanium plate removal by age group and fracture site.

	Scheduled, *n*	Aesthetic reasons, *n*	Pain, *n*	Infection, *n*	Other, *n*	Total, *n* (%)
Zygomaticomaxillary buttress						
≤6	2	3	1	0	0	6
7–12	6	0	3	1	1	11
13–16	6	0	0	1	2	9
Total	14	3	4	2	3	26/58 (45%)
Inferior orbital rim						
≤6	1	0	0	0	0	1
7–12	2	2	0	1	0	5
13–16	0	0	0	0	0	0
Total	3	2	0	1	0	6/16 (38%)
Fronto-zygomatic suture						
≤6	1	0	0	0	0	1
7–12	3	0	0	0	0	3
13–16	1	0	0	0	0	1
Total	5	0	0	0	0	5/22 (23%)
All sites						
≤6	4	3	1	0	0	8/8 (100%)
7–12	11	2	3	2	1	19/30 (63%)
13–16	7	0	0	1	2	10/58 (17%)
Total	22 (59%)	5 (14%)	4 (11%)	3 (8%)	3 (8%)	37/96 (39%)

4 | DISCUSSION

The principles of surgical treatment for paediatric MZC fractures do not differ from those in adults.[19,20] The MZC is a quadripod structure, and the fixation points that can be used for its stabilisation through osteosynthesis are the zygomaticomaxillary buttress, the infraorbital rim, and the frontozygomatic and the zygomaticotemporal sutures. Internal fixation with plates and screws is currently considered the gold standard for displaced and comminuted fractures in both adults,[20–22] and the paediatric population,[4,5,7,14,16,23] because it provides a stable three-dimensional reconstruction, promotes primary bone healing, and shortens the treatment duration. In adults, recent systematic reviews on the surgical treatment of these quadripod injuries concluded that a three-point, as opposed to a two-point, fixation provides greater stability and reduces malar asymmetry.[24,25] A few studies have argued that one-point fixation of the zygomaticomaxillary buttress is sufficient in non-comminuted MZC fractures.[26–29] By contrast, in the paediatric population, there is a lack of clear indications regarding the method of MZC fixation. While there is a general consensus in the literature on the use of ORIF in patients with displaced or complex fractures, as confirmed in this study, the relative rarity of such fractures together with caution in the use of titanium plate osteosynthesis, due to its potential interference with bone growth and the presence of tooth germs in patients with deciduous or mixed dentition, has contributed to the limited and often controversial data.[4,5,7,9,15,16] In the study by Imahara et al.,[1] only 15% of the paediatric fractures seen in the emergency department involved the MZC, while a recent review on indications for titanium osteosynthesis in paediatric trauma by Vercruysse et al.[15] found that 18% of the patients with displaced MZC fractures underwent titanium ORIF; compared to 79% of the patients with displaced mandibular fractures. The absence of patients with MZC fractures treated with ORIF in 5 out of the 14 centres participating in the WORMAT project provides further evidence of their relative rarity.

In this study there was general uniformity in the surgical management of MZC fractures, as nearly all patients in all age groups had displaced fractures treated with titanium plate osteosynthesis. Fixation often involved an intraoral approach to the zygomaticomaxillary buttress, similar to fixation in adults and consistent with the approach described in the only paper focusing on the repair of paediatric MZC fractures.[14] The clear preference for an intraoral approach among the participating centres, as well as in the study by Luck et al.,[14] reflects the intention to achieve a valid reduction and stable fixation through a gingivobuccal incision, avoiding an external scar. In this study, the use of 4-mm screws and their angulation away from tooth germs, as recommended by Deguchi et al.,[30] avoided damaging the tooth germs, as evidenced by the absence of dental complications in patients with deciduous and mixed dentition, consistent with the findings reported by Luck et al.[14]

However, unlike Luck et al.[14] and Allred et al.,[5] who preferred two-point fixation, centres of the WORMAT project consistently treated displaced MZC fractures with single-point fixation in patients

≤6 years of age and in more than two-thirds of the patients overall. Only in 4 out of the 35 patients aged 13–16 years was three-point fixation performed (Table 2). Single-point fixation, either alone or in combination with a second point, was considered adequate by Zimmermann et al.[4] and Defazio et al.[16] Yet, both authors agreed on the use of the frontozygomatic suture and the infraorbital rim as the first and second fixation points to avoid damage to tooth germs, even if potentially resulting in aesthetically undesirable external scars.

The almost exclusive use of titanium plates is consistent with previous reports that they did not interfere with skeletal growth.[8,15,23] However, in this study, in centres where ORIF was performed in patients ≤6 years of age, all titanium plates were removed. According to a recent review, the removal of titanium plates in children is not standard practice, and removal rates vary from 0% to 40% depending on the fracture site, typically the mandible.[15] In this study, a significant decreasing trend in plate removal was determined, with removal rates decreasing from 100% to 17% with increasing age (Table 4). The reasons for plate removal in previous studies were unclear. Luck et al.[14] reported plate removal in 2 of 30 patients, in 1 case due to infection (3.3%) compared to 3 such cases in this study, (4.7%), and in another case due to hardware extrusion.

Finally, regarding the residual notable asymmetry in five patients with MZC fractures, the senior authors of the participating centers agree that the most likely cause was imperfect correction of the quadripod injury. Overall, the percentage of postoperative complications in this study is consistent with that reported by DeFazio et al.[16] in a review of outcomes in children treated for zygomatic fractures.

The main strength of this study is its multicenter nature, which resulted in the collection of the largest paediatric population reported in the literature to date. The limitations included its retrospective design and the possible biases deriving from it, such as sampling and information bias. The surgical procedures were performed by different maxillofacial surgeons at different centres. Therefore, the experience of the surgeon may have affected the results. Additionally, despite the 11-year time span, the long-term outcomes concerning the development of tooth germs and the facial skeleton after plate osteosynthesis are unknown due to the relatively short follow-up. However, younger patients are usually followed by their attending physicians and, according to Luck et al.,[14] "would be expected to return for visit(s) with the surgeon who performed their zygomaticomaxillary complex fracture repair if dental or other complications developed".

Future prospective studies with long-term follow-up are needed to establish definitive surgical protocols and identify long-term potential risks and complications.

5 | CONCLUSION

This multicentric retrospective study showed that ORIF with titanium plates, even with a single point of internal fixation, is a safe and effective method to treat displaced quadripod MZC fractures in the paediatric population, as supported by the low incidence of postoperative complications and residual facial asymmetries. Among the participating centres, a preference was found in the use of a single-point fixation and in the selection of the zygomaticomaxillary buttress as a site of fixation.

AUTHOR CONTRIBUTIONS

Dr Fabio Roccia, Sobrero Federica, Carlo Strada: concept, design, research, analysis, interpretation of data, preparation, and critical review of the manuscript. Dr Gian Battista Bottini, Maximilian Goetzinger, Sahand Samieirad, Aleš Vesnaver, Anže Birk, Luis Fernando de Oliveira Gorla, Valfrido Antonio Pereira-Filho, Emil Dediol, Boris Kos, Petia Pechalova, Angel Sapundzhiev, Marko Lazíc, Vitomir S. Konstantinovic, Kathia Dubron, Constantinus Politis, Paolo Garzino Demo, Anamaria Sivrić, Mario Kordić, Sajjad Abdur Rahman, Tabishur Rahman, Karpal Singh Sohal, Timothy Aladelusi, Euan Rae, Sean Laverick: data collection, critical review of the manuscript.

FUNDING INFORMATION

This research received no external funding.

CONFLICT OF INTEREST STATEMENT

None of the authors have any relevant financial relationship(s) with a commercial interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Federica Sobrero https://orcid.org/0000-0002-2473-3802
Boris Kos https://orcid.org/0000-0002-7798-7566
Kathia Dubron https://orcid.org/0000-0003-1275-2771

REFERENCES

1. Imahara SD, Hopper RA, Wang J, Rivara FP, Klein MB. Patterns and outcomes of pediatric facial fractures in the United States: a survey of the National Trauma Data Bank. J Am Coll Surg. 2008;207:710–6. https://doi.org/10.1016/j.jamcollsurg.2008.06.333
2. Vyas RM, Dickinson BP, Wasson KL, Roostaeian J, Bradley JP. Pediatric facial fractures: current national incidence, distribution, and health care resource use. J Craniofac Surg. 2008;19:339–49. https://doi.org/10.1097/SCS.0b013e31814fb5e3
3. Roccia F, Iocca O, Sobrero F, Rae E, Laverick S, Carlaw K, 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–e857. https://doi.org/10.1016/j.jormas.2022.05.004
4. Zimmermann CE, Troulis MJ, Kaban LB. Pediatric facial fractures: recent advances in prevention, diagnosis and management. Int J Oral Maxillofac Surg. 2005;34:823–33. https://doi.org/10.1016/j.ijom.2005.09.014

5. 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. https://doi.org/10.1097/SCS.0000000000002087
6. Segura-Palleres I, Sobrero F, Roccia F, de Oliveira Gorla LF, Pereira-Filho VA, Gallafassi D, et al. Characteristics and age-related injury patterns of maxillofacial fractures in children and adolescents: a multicentric and prospective study. Dental Traumatol. 2022;38:213–22. https://doi.org/10.1111/edt.12735
7. Iatrou I, Theologie-Lygidakis N, Tzerbos F. Surgical protocols and outcome for the treatment of maxillofacial fractures in children: 9 years' experience. J Craniomaxillofac Surg. 2010;38:511–6. https://doi.org/10.1016/j.jcms.2010.02.008
8. Siy RW, Brown RH, Koshy JC, Stal S, Hollier LH. General management considerations in pediatric facial fractures. J Craniofac Surg. 2011;22:1190–5. https://doi.org/10.1097/SCS.0b013e31821c0cf9
9. Grunwaldt L, Smith DM, Zuckerbraun NS. Pediatric facial fractures: demographics, injury patterns, and associated injuries in 772 consecutive patients. Plast Reconstr Surg. 2011;128:1263–71. https://doi.org/10.1097/PRS.0b013e318230c8cf
10. Eskitascioglu T, Ozyagan I, Coruh A, Gunay GK, Yuksel E. Retrospective analysis of two hundred thirty-five pediatric mandibular fractures cases. Ann Plast Surg. 2009;63:522–30. https://doi.org/10.1097/SAP.0b013e318194fdab
11. Smith DM, Bykowski MR, Cray JJ, Naran S, Rottgers SA, Shakir S, et al. 215 mandible fractures in 120 children: demographics, treatment, outcomes, and early growth data. Plast Reconstr Surg. 2013;131:1348–58. https://doi.org/10.1097/PRS.0b013e31828bd503
12. Bobrowski AN, Torriani MA, Sonego CL, Carvalho PD, Post LK, Júnior OC. Complications associated with the treatment of fractures of the dentate portion of the mandible in pediatric patients: a systematic review. Int J Oral Maxillofac Surg. 2017;46:465–72. https://doi.org/10.1016/j.ijom.2016.12.010
13. 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. https://doi.org/10.1016/j.joms.2020.12.022
14. Luck JD, Lopez J, Faateh M, Macmillan A, Yang R, Davidson EH, et al. Pediatric zygomaticomaxillary complex fracture repair: location and number of fixation sites in growing children. Plast Reconstr Surg. 2018;142:51E–60E. https://doi.org/10.1097/PRS.0000000000004487
15. 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. https://doi.org/10.1016/j.jormas.2022.09.005
16. Defazio MV, Fan KL, Avashia YJ, Danton GH, Thaller SR. Fractures of the pediatric zygoma: a review of the clinical trends, management strategies, and outcomes associated with zygomatic fractures in children. J Craniofac Surg. 2013;24:1891–7. https://doi.org/10.1097/SCS.0b013e3182a24659
17. Zingg M, Laedrach K, Chen J, Chowdhury K, Vuillemin T, Sutter F, et al. Classification and treatment of zygomatic fractures: a review of 1,025 cases. J Oral Maxillofac Surg. 1992;50:778–90. https://doi.org/10.1016/0278-2391(92)90266-3
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. https://doi.org/10.1111/edt.12814
19. Hollier LH. Pediatric zygomaticomaxillary complex fracture repair: location and number of fixation sites in growing children. Plast Reconstr Surg. 2018;142:61E–62E. https://doi.org/10.1097/PRS.0000000000004488
20. Zellner E, Forrest CF. Pediatric midface fractures. In: Dorafshar AH, Rodriguez ED, Manson PN, editors. Facial trauma surgery: from primary repair to reconstruction. 1st ed. Amsterdam: Elsevier; 2019. p. 310.
21. Ellis E, Kittidumkerng W. Analysis of treatment for isolated zygomaticomaxillary complex fractures. J Oral Maxillofac Surg. 1996;54:386–400. https://doi.org/10.1016/S0278-2391(96)90107-X
22. Kelley P, Hopper R, Gruss J. Evaluation and treatment of zygomatic fractures. Plast Reconstr Surg. 2007;120:5–15. https://doi.org/10.1097/01.prs.0000260720.73370.d7
23. Haug RH, Foss J. Maxillofacial injuries in the pediatric patient. Oral Surg Oral Pathol Oral Radiol Endod. 2000;90:126–34. https://doi.org/10.1067/moe.2000.107974
24. Gadkari N, Bawane S, Chopra R, Bhate K, Kulkarni D. Comparative evaluation of 2-point vs 3-point fixation in the treatment of zygomaticomaxillary complex fractures – A systematic review. J Cranio-Maxillofacial Surg. 2019;47:1542–50. https://doi.org/10.1016/j.jcms.2019.07.009
25. Jazayeri HE, Khavanin N, Yu JW, Lopez J, Shamliyan T, Peacock ZS, et al. Fixation points in the treatment of traumatic zygomaticomaxillary complex fractures: a systematic review and meta-analysis. J Oral Maxillofac Surg. 2019;77:2064–73. https://doi.org/10.1016/j.joms.2019.04.025
26. Kim JH, Lee JH, Hong SM, Park CH. The effectiveness of 1-point fixation for zygomaticomaxillary complex fractures. Arch Otolaryngol Head Neck Surg. 2012;138:828–32. https://doi.org/10.1001/archoto.2012.1815
27. Kim ST, Go DH, Jung JH, Cha HE, Woo JH, Kang IG. Comparison of 1-point fixation in treating tripod fractures of the zygoma. J Oral Maxillofac Surg. 2011;69:2848–52. https://doi.org/10.1016/j.joms.2011.02.073
28. Sato A, Imai Y, Muraki K, Tachi M. Reliability of ultrasound-guided one-point fixation for zygomaticomaxillary complex fractures. J Craniofac Surg. 2019;30:218–22. https://doi.org/10.1097/SCS.0000000000005133
29. Shokri T, Sokoya M, Cohn JE, Bahrami A, Inman J, Duric Y. Single-point fixation for noncomminuted zygomaticomaxillary complex fractures–A 20-year experience. J Oral Maxillofac Surg. 2020;78:778–81. https://doi.org/10.1016/j.joms.2019.12.030
30. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. Am J Orthod Dentofacial Orthop. 2006;129(721):e7–e12. https://doi.org/10.1016/j.ajodo.2006.02.026

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Roccia F, Sobrero F, Strada C, Bottini GB, Goetzinger M, Samieirad S, et al. Open reduction and internal fixation of paediatric maxillozygomatic complex fractures: An 11-year multicentric retrospective study. Dental Traumatology. 2024;40:680–687. https://doi.org/10.1111/edt.12976