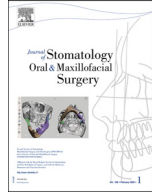




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Original Article

## An 11-year multicentric surgical experience on pediatric orbital floor trapdoor fracture: A World Oral Maxillofacial Trauma (WORMAT) project



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### ABSTRACT

**Introduction:** Trapdoor fractures of the orbital floor occur almost exclusively in the paediatric population. Despite being widely discussed in the literature, their management remains controversial. The objective of this retrospective study was to analyse the surgical experiences on paediatric trapdoor fractures in the maxillofacial centres participating in the WORMAT project.

**Materials and methods:** 14 centres collected data for patients aged ≤16 years operated between January 2011 and December 2022. The demographic, cause and type of fracture, timing from injury to surgery, surgical approach, type of floor repair and outcomes were recorded. Diplopia, surgical wound infection, hardware loosening and dysesthesia in the infraorbital nerve area were recorded at follow-up.

**Results:** 43 patients were included: 25 children (0–12 y) and 18 adolescents (13–16 y) (mean age, 11.1 years). Surgical treatment was performed within 24 h in 51 % of the patients, within 24–72 h in 33 %, and beyond 72 h in the remaining. The orbital floor was repaired with a resorbable implant/membrane in 63 % of the patients, open reduction without an implant in 30 %, a titanium mesh implant in 3 adolescent patients. At follow-up (mean 16.3 months), 14 patients had residual diplopia in the upper fields, only two of these resolved within 6 months.

**Discussion:** A tendency toward an increased incidence of postoperative diplopia with longer intervals between trauma and surgery was observed. This study showed different choices regarding the material placed on the floor, with a preference for open reduction without implants in children, compared to the use of resorbable implants or membranes in adolescents.

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## 1. Introduction

Orbital trapdoor fractures predominantly affect the orbital floor and, less frequently, the medial wall, occurring almost exclusively in paediatric patients [1]. Owing to greater bone elasticity in children than in adults, linear greenstick fractures or minimal medial hinged fractures of the orbital floor can occur, leading to entrapment of orbital tissues such as fat, connective tissue, and extraocular muscles (EOM) [2–4].

Despite being first defined in 1965 by Soll and Poley [2] and widely discussed in the literature, the timing of treatment and surgical management of trapdoor fractures remain controversial [5–8].

The relative rarity of these fractures and the possibility of them being treated by specialists from different fields may explain the diversity of management approaches [7].

Therefore, the objective of this retrospective multicentre study was to analyse the treatment experiences of paediatric orbital floor trapdoor fractures in 14 maxillofacial surgery centres participating in the World Oral Maxillofacial Trauma (WORMAT) project [9], particularly evaluating timing, surgical management choices, and outcomes.

## 2. Materials and methods

As part of the WORMAT project, 14 maxillofacial surgery centres (Table 1) agreed to collect data in an Excel database for all patients aged  $\leq 16$  years operated on for maxillofacial fractures under general anaesthesia between January 2011 and December 2022. A PDF file was sent to the centres with instructions on how to compile the database correctly.

This retrospective study included patients with orbital floor trapdoor fractures diagnosed through clinical evaluation (diplopia with limited extrinsic ocular movements) and confirmed via axial and

coronal computed tomography. Patients with incomplete clinical and radiological records and a follow-up period of less than 6 months were excluded.

The collected data included age, sex, cause of fracture (categorised into road traffic accidents, falls, assaults, sports injuries, other), type of trapdoor fracture (1a or 1b) according to the Gerbino et al. [4] classification, timing from injury to surgery ( $<24$  h, 24–72 h,  $>72$  h), perioperative use of antibiotics and/or steroids, surgical approach (categorised into lower lid, transconjunctival, translesional), type of surgical floor repair, and outcomes.

The patients were divided into two age groups: children (0–12 years) and adolescents (13–16 years).

Orbital floor repair methods were classified as open reduction without implants, orbital implants (resorbable or titanium), orbital floor membranes, and others.

The minimum follow-up period was 6 months. The following postoperative complications were recorded: temporary ( $<6$  months) and permanent ( $\geq 6$  months) diplopia, surgical wound infection/dehiscence, hardware loosening/displacement, and post-traumatic sensory changes (paraesthesia, hypoesthesia, or anaesthesia) in the infraorbital nerve area. Wound infection was assessed clinically and defined as oedema, induration with erythema, or purulent discharge from the surgical site [10]. Diplopia and ocular motility were assessed clinically and confirmed with the Hess–Lancaster test.

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

### 2.1. Data analysis

Statistical analyses were performed using the SPSS software (version 29.0.2.0; IBM Corp., Armonk, NY, USA). Predictors and outcomes were analysed using Fisher's exact test and the chi-squared test, as appropriate. All statistical analyses were two-tailed. The significance level was set at  $p < 0.05$ .

## 3. Results

Of the 756 paediatric patients who underwent surgery for maxillofacial fractures, 43 (6 %) (30 males and 13 females; male to female [M:F] ratio, 2.3:1) aged between 4 and 16 years (mean age, 11.1 years; standard deviation [SD], 3.7) from 8 out of 14 centres met the inclusion criteria. Of these, 25 were children and 18 were adolescents.

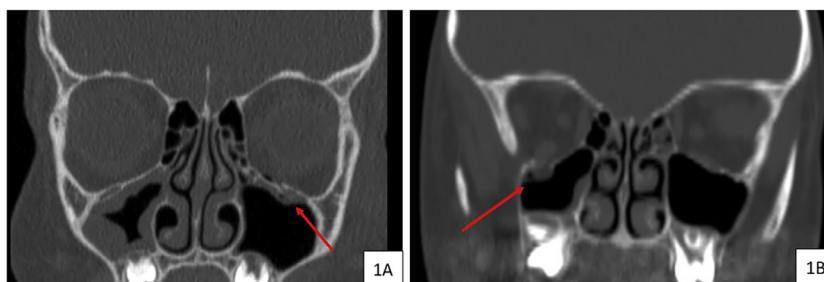
Sixty percent of trapdoor fractures occurred due to sports injuries, followed by falls and assaults, resulting in 23 patients with type 1a trapdoor fractures (14 children and 9 adolescents) and 20 patients with type 1b trapdoor fractures (11 children and 9 adolescents) (Fig. 1). Type 1a fractures were slightly more frequent in children (56 %) than in adolescents (50 %) ( $p = 0.70$ , chi-squared test). Type 1a fractures more frequently resulted from sports injuries in both children (57 %) and adolescents (56 %), similar to type 1b fractures (45 % in children and 89 % in adolescents; Table 2).

Surgical treatment was performed within 24 h in half of the patients (15 children and 7 adolescents), within 24–72 h in one-third (7 children and adolescents each), and beyond 72 h in the remaining patients (3 children and 4 adolescents) (Table 3).

Eighty-one percent of patients received antibiotic therapy, either combined with steroid therapy (21 patients) or alone (14 patients). The remaining 8 patients did not receive any perioperative medical therapy. The types of treatment for trapdoor fractures based on age group and fracture type are summarised in Table 3, highlighting that the transconjunctival approach was performed in more than two-thirds of the patients. After releasing the trapped endo-orbital tissues, a resorbable implant/membrane was placed in most patients (63 %) (15 children and 12 adolescents), while open reduction without an

**Table 1**  
Maxillofacial surgery units participating in the WORMAT pediatric project.

Country	City	Affiliation
Austria	Salzburg	Dpt. Oral and Maxillofacial Surgery, Paracelsus Medical University
Belgium	Leuven	Dpt. Oral and Maxillofacial Surgery, University Hospitals Leuven
Bosnia and Herzegovina	Mostar	Clinic for ENT and OMS University Clinical Hospital
Brazil	São Paulo	Dpt. Diagnosis and Surgery, Araraquara Dental School – UNESP - State University
Bulgaria	Plovdiv	Dpt. Maxillofacial Surgery, Medical University
Croatia	Zagreb	Dpt. Maxillofacial Surgery, University Hospital Dubrava
India	Aligarh	Dpt. Oral and Maxillofacial Surgery, Aligarh Muslim University
Iran	Mashhad	Dpt. Oral and Maxillofacial Surgery, Mashhad dental school, University of Medical Sciences
Italy	Turin	Division of Maxillofacial Surgery, Città della Salute e della Scienza, University of Turin
Nigeria	Ibadan	Dpt. Oral and Maxillofacial Surgery, College of Medicine, University of Ibadan
Serbia	Belgrade	Clinic of Maxillofacial Surgery, School of Dental Medicine, University of Belgrade
Slovenia	Ljubljana	Dpt. Maxillofacial and Oral Surgery, University Medical Centre
Tanzania	Muhimbili	Dpt. Oral and Maxillofacial Surgery, University of Health and Allied Sciences
United Kingdom	Dundee	Dpt. Oral and Maxillofacial Surgery, University of Dundee



**Fig. 1.** Trapdoor fracture with endo-orbital tissue entrapment. Coronal CT scan showing linear trapdoor fracture type 1a (1A) and type 1b (1B) of the orbital floor.

implant was performed in 30 % of the cases (10 children and 3 adolescents). Only 3 adolescent patients received a titanium mesh implant.

Open reduction without implants was more frequently used in children (40 %) than in adolescents (17 %) and in type 1a fractures (35 %) than in type 1b fractures (25 %), although these differences did not reach statistical significance ( $p = 0.09$  and  $p = 0.48$ , respectively).

At a mean follow-up of 16.3 months (SD 16.7), 14 patients (32 %) had residual diplopia in the upper fields; only two of these resolved within 6 months (Table 4). Analysis of the study variables in the 12 patients with permanent diplopia is shown in Table 5. Specifically, 6 patients were treated with open reduction without implants, 5 with orbital membrane placement, and one with titanium mesh. No statistically significant association was found between permanent postoperative diplopia and age, fracture type, timing of treatment, or type of treatment ( $p > 0.05$ , Fisher's exact test for all comparisons). However, there was a tendency for an increased incidence of postoperative diplopia with longer intervals between trauma and surgery (23 % within 24 h, 29 % between 24 and 72 h, and 43 % beyond 72 h) (Table 5).

#### 4. Discussion

This retrospective analysis of surgical experiences in treating orbital floor trapdoor fractures in 43 children and adolescents over more than a decade highlighted the relative rarity of this type of injury. This rarity is confirmed by the fact that 6 out of the 14 maxillofacial surgery centres participating in the WORMAT project did not have any patients who required surgery for this condition.

The study also reported that patients with this unusual type of orbital fracture exhibit epidemiological characteristics similar to those found in previous papers, including age (mean age 11 years), sex (predominantly male), and cause of injury (primarily sports-related injuries) [1,4,11–13].

Traumatic events, which typically affect the lower portion of the orbit in the paediatric population, can frequently result in the fracture of a particularly elastic orbital floor, as the bone is less mineralised and more flexible [13–15]. These characteristics allow part of the endo-orbital contents to dislocate into the underlying maxillary

**Table 2**  
Summary of patients' characteristics and cause of trauma, stratified by type of orbital floor trapdoor fracture.

Fracture type	Age mean (SD)	Sex n (%)		Cause of trauma n (%)					Total n (%)	
		M	F	Sport	Fall	Assault	Other	RTA		
<b>Trapdoor type 1A</b>	10.3 (4.0)	15	8	13	5	3	1	1	<b>23 (53 %)</b>	
children		9	5	8	4	0	1	1		14 (32 %)
adolescents		6	3	5	1	3	0	0		9 (21 %)
<b>Trapdoor type 1B</b>	12.1 (3.2)	15	5	13	4	1	2	0	<b>20 (47 %)</b>	
children		8	3	5	3	1	2	0		11 (26 %)
adolescents		7	2	8	1	0	0	0		9 (21 %)
<b>Total</b>	<b>11.1 (3.7)</b>	<b>30 (70 %)</b>	<b>13 (30 %)</b>	<b>26 (60 %)</b>	<b>9 (21 %)</b>	<b>4 (9 %)</b>	<b>3 (7 %)</b>	<b>1 (3 %)</b>	<b>43 (100 %)</b>	

Abbreviations: RTA: Road traffic accident, SD: standard deviation.

**Table 3**  
Timing and surgical treatment of orbital floor trapdoor fractures.

	Fracture type						Total
	Trapdoor type 1A			Trapdoor type 1B			
	Children n (%)	Adolescents n (%)	Total n (%)	Children n (%)	Adolescents n (%)	Total n (%)	
<b>Timing of surgery</b>							
< 24h	8	3	11 (48 %)	7	4	11 (55 %)	<b>22 (51 %)</b>
24 – 72 h	4	3	7 (30 %)	3	4	7 (35 %)	<b>14 (33 %)</b>
> 72h	2	3	5 (22 %)	1	1	2 (10 %)	<b>7 (16 %)</b>
<b>Surgical approach</b>							
Transconjunctival	10	7	17 (74 %)	8	5	13 (65 %)	<b>30 (70 %)</b>
Lower eyelid	4	2	6 (26 %)	3	3	6 (30 %)	<b>12 (28 %)</b>
Translesional	–	–	–	–	–	1 (5 %)	<b>1 (2 %)</b>
<b>Type of treatment</b>							
Orbital membrane (Lyoplast or similar)	5	5	10 (44 %)	7	2	9 (45 %)	<b>19 (44 %)</b>
Open reduction with no implant	6	2	8 (35 %)	4	1	5 (25 %)	<b>13 (30 %)</b>
Orbital implant resorbable	3	2	5 (21 %)	–	3	3 (15 %)	<b>8 (19 %)</b>
Titanium mesh	–	–	–	–	3	3 (15 %)	<b>3 (7 %)</b>

**Table 4**  
Postoperative complications by type of orbital floor trapdoor fracture between children and adolescents.

	Trapdoor type 1A (n = 23)			Trapdoor type 1B (n = 20)			Total (n = 43)
	Children n	Adolescents n	Total n (%)	Children n	Adolescents n	Total n (%)	
Temporary diplopia	–	2	2 (9 %)	–	–	–	2 (5 %)
Persistent diplopia	7	2	9 (39 %)	2	1	3 (15 %)	12 (28 %)
Surgical wound infection	–	–	–	–	1	1 (5 %)	1 (2 %)

**Table 5**  
Incidence of persistent diplopia by study variables.

	Persistent diplopia n (%)	Favorable outcome n	P value
<b>Age group</b>			> 0.05*
Children	9 (36 %)	16	
Adolescents	3 (17 %)	15	
<b>Type of fracture</b>			> 0.05*
Trapdoor type 1A	9 (39 %)	14	
Trapdoor type 1B	3 (15 %)	17	
<b>Time of treatment</b>			> 0.05*
> 72 h	3 (43 %)	4	
24–72 h	4 (29 %)	10	
< 24h	5 (23 %)	17	
<b>Type of treatment</b>			> 0.05*
Open reduction with no implant	6 (46 %)	7	
Titanium mesh	1 (33 %)	2	
Orbital membrane	5 (26 %)	14	
Orbital floor implant resorbable	–	8	

\* Fisher Exact text.

sinus before spontaneously reducing to their pre-injury position, causing immediate diplopia owing to the mechanical restriction of the EOM. The spontaneous reduction can be complete, resulting in a linear fracture, or incomplete, with minimal displacement of part of the floor hinged medially [4,11,13,16,17].

By standardising the classification of trapdoor fractures according to Gerbino et al. [4] among all WORMAT centres, this study showed a slightly higher incidence of linear type 1a fractures in children than in adolescents (Table 2), although this was not statistically significant. The progressive loss of bone elasticity during growth leads to an increase in minimally displaced type 1b fractures in adolescents, as reported in several studies [4,18–20].

Although the literature reports that the timing of treatment for orbital floor trapdoor fractures is controversial, this retrospective study showed relative uniformity, with nearly all patients operated within 72 h. This consistent choice among the maxillofacial centres participating in this project aligns with most published studies that recommend operating on paediatric trapdoor fractures as soon as possible or within 72 h to decrease the incidence of residual postoperative diplopia. Conversely, only ophthalmology-related papers [16,21–24] still suggest surgical treatment beyond the 72-h window recommended by not only maxillofacial [4,15,25–27] but also plastic and reconstructive [1,12,13,18] and otolaryngology authors [28].

This study among maxillofacial centres also found a trend towards an increased incidence of postoperative diplopia with longer intervals between trauma and treatment, although this was not statistically significant, considering the small number of patients treated >72 h (Table 5). The indication for early treatment is based on biological reasons such as EOM entrapment, which, if not promptly resolved, leads to ischaemia and fibrosis with irreversible scarring [1,4,26,29]. Nonetheless, it is essential to consider that postoperative diplopia can have multifactorial origins, including incomplete release of herniated tissues and traumatic neurogenic injuries; therefore, the

timing of surgery should not be considered the sole factor influencing visual outcomes [1,4,13,29].

Regarding surgical management, the transconjunctival approach was more frequently selected among the centres. This approach provides adequate exposure of the fracture while avoiding unsightly scarring in young patients.

However, the choice of material to be placed after complete release of the entrapped endo-orbital tissues varied among centres. In the absence of a consensus on the best type of material to place on the orbital floor, the literature shows a prevalence in the use of resorbable implants or membranes owing to concerns regarding potential growth restrictions and entrapment within the remodelling bone [4,6,11–13,15,23,24,29]. This choice was observed in more than two-thirds of the patients in this study, particularly in adolescents. Open reduction without implants, only reported by Karthik et al., [26] was more frequent in type 1a fractures than in type 1b fractures, albeit without statistically significant differences. Finally, the use of titanium mesh was reserved only for adolescent patients, as reported by various authors [12,23,24,30].

The limitations of this study include its retrospective nature and the fact that the type of endo-orbital tissue entrapped in the floor trapdoor was not reported. Another limitation of this study is that the surgical procedures were performed by different maxillofacial surgeons at various centres; therefore, the experience of the surgeon may have affected the results.

**5. Conclusions**

This decade-long retrospective study on the surgical experiences of maxillofacial centres participating in the WORMAT project showed a nearly uniform choice in the timing of treatment for orbital floor trapdoor fractures, with most patients treated within 72 h. A tendency towards a decreased incidence of postoperative diplopia with shorter intervals between trauma and surgery was observed. However, the study showed different choices regarding the material placed after releasing the trapped endo-orbital tissues, with a tendency to prefer open reduction without implants in children, compared to the use of resorbable implants or membranes in adolescents.

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