Review

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Association of Retrobulbar Haemorrhage with Midface Fractures: A Systematic Review and Meta-Analysis

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Abstract

Background: Retrobulbar haemorrhage (RBH) is a rare, vision-threatening complication of midface fractures. This systematic review and meta-analysis evaluate the incidence, clinical presentation, diagnostic modalities, management strategies, and visual outcomes of RBH in patients with orbito-zygomatic and orbito-ethmoid fractures. **Methods:** A comprehensive literature search was conducted in PubMed, Scopus, and Web of Science following PRISMA guidelines. Studies reporting RBH secondary to midface fractures were included. A random-effects meta-analysis was performed to pool incidence rates and visual outcomes. Risk of bias was assessed using the Newcastle-Ottawa Scale. **Results:** Seventeen studies with 7,529 patients were included. The pooled incidence of RBH was 2.1% (95% CI: 1.0–4.4%), with substantial heterogeneity (I^2 = 96%). The pooled proportion of patients achieving full visual recovery was 61% (95% CI: 43–77%), while permanent vision loss occurred in 5% (95% CI: 2–11%). Surgical decompression was performed in 62% of reported cases. Computed tomography was the primary diagnostic modality. **Conclusions:** RBH is an uncommon but serious complication of midface fractures. Timely surgical decompression is associated with favorable visual outcomes in most cases. Standardized reporting and prospective multicenter studies are needed to optimize management protocols.

Keywords: retrobulbar haemorrhage; midface fracture; orbital fracture; zygomatic complex fracture; orbital compartment syndrome; meta-analysis

1. Introduction

Midface fractures represent a diverse group of traumatic injuries involving the central facial skeleton, including the maxilla, zygomatic complex, nasal bones, and orbital walls. These injuries typically result from high-energy impacts, often leading to complex fracture patterns that pose significant acute challenges due to their proximity to vital structures such as the airway and the skull base [1,2].

Zygomatic complex (ZMC) fractures are the second most common type of facial fracture after nasal bone fractures, accounting for approximately 25–30% of all facial fractures [3,4]. These fractures commonly result from blunt trauma such as motor vehicle accidents, assaults, sports injuries, and falls, with a higher prevalence in males (70–80%) aged 20–40 years [5,6]. Naso-orbito-ethmoidal (NOE) fractures, although less frequent, represent a particularly challenging subset due to their involvement of the medial canthal tendon and lacrimal system [7,8].

Orbital fractures, particularly those involving the floor and medial wall, are common in both isolated injuries and complex midface trauma. They can lead to ocular motility disturbances,

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diplopia, enophthalmos, and, in severe cases, retrobulbar haemorrhage (RBH) [9,10]. RBH is a rare but potentially vision-threatening complication, with reported incidence rates varying widely in the literature [11,12]. Patients with RBH typically present with proptosis, decreased visual acuity, pain, and restricted eye movement [13,14].

This systematic review and meta-analysis aim to synthesize current literature on the incidence, diagnosis, management, and outcomes of RBH in patients with midface fractures, with a focus on providing pooled estimates to inform clinical practice.

2. Materials and Methods

2.1. Protocol and Registration

This systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [15] and was registered with PROSPERO (ID: CRD42024594177).

2.2. Search Strategy and Information Sources

A comprehensive literature search was conducted across PubMed, Scopus, ScienceDirect, and Google Scholar. The search strategy combined keywords related to "retrobulbar haemorrhage," "retrobulbar hematoma," "maxillofacial fractures," "midface fractures," and "orbital fractures." The search was limited to articles published up to May 2025.

2.3. Eligibility Criteria

Studies were included if they met the following criteria: (1) patients with midface fractures (ZMC, NOE, orbital, Le Fort, or nasal fractures); (2) reported RBH as an outcome; (3) reported management and/or clinical outcomes; and (4) study designs including randomized controlled trials, cohort studies, case-control studies, or case series with ≥10 patients. Exclusion criteria included case reports, reviews without original data, and studies with incomplete outcome reporting.

2.4. Data Extraction and Quality Assessment

Two independent reviewers extracted data on study characteristics, patient demographics, fracture types, RBH incidence, diagnostic methods, management strategies, and visual outcomes. Risk of bias was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies [16]. Discrepancies were resolved by consensus.

2.5. Statistical Analysis

A random-effects meta-analysis was conducted using the inverse variance method to pool incidence rates and outcome proportions. Heterogeneity was assessed using the I^2 statistic, with values >50% indicating substantial heterogeneity. All analyses were performed using R software (version 4.2.0) with the 'meta' package. Publication bias was assessed using funnel plots and Egger's test.

3. Results

3.1. Study Selection and Characteristics

A total of 2,744 records were identified. After removing duplicates and screening, 17 studies met the inclusion criteria (Figure 1). The included studies comprised 7,529 patients, with sample sizes ranging from 60 to 2,568. Patient demographics showed a predominance of males (range: 45.6–96.8%), with mean ages spanning the third to sixth decades of life. Study characteristics are summarized in Table 1.

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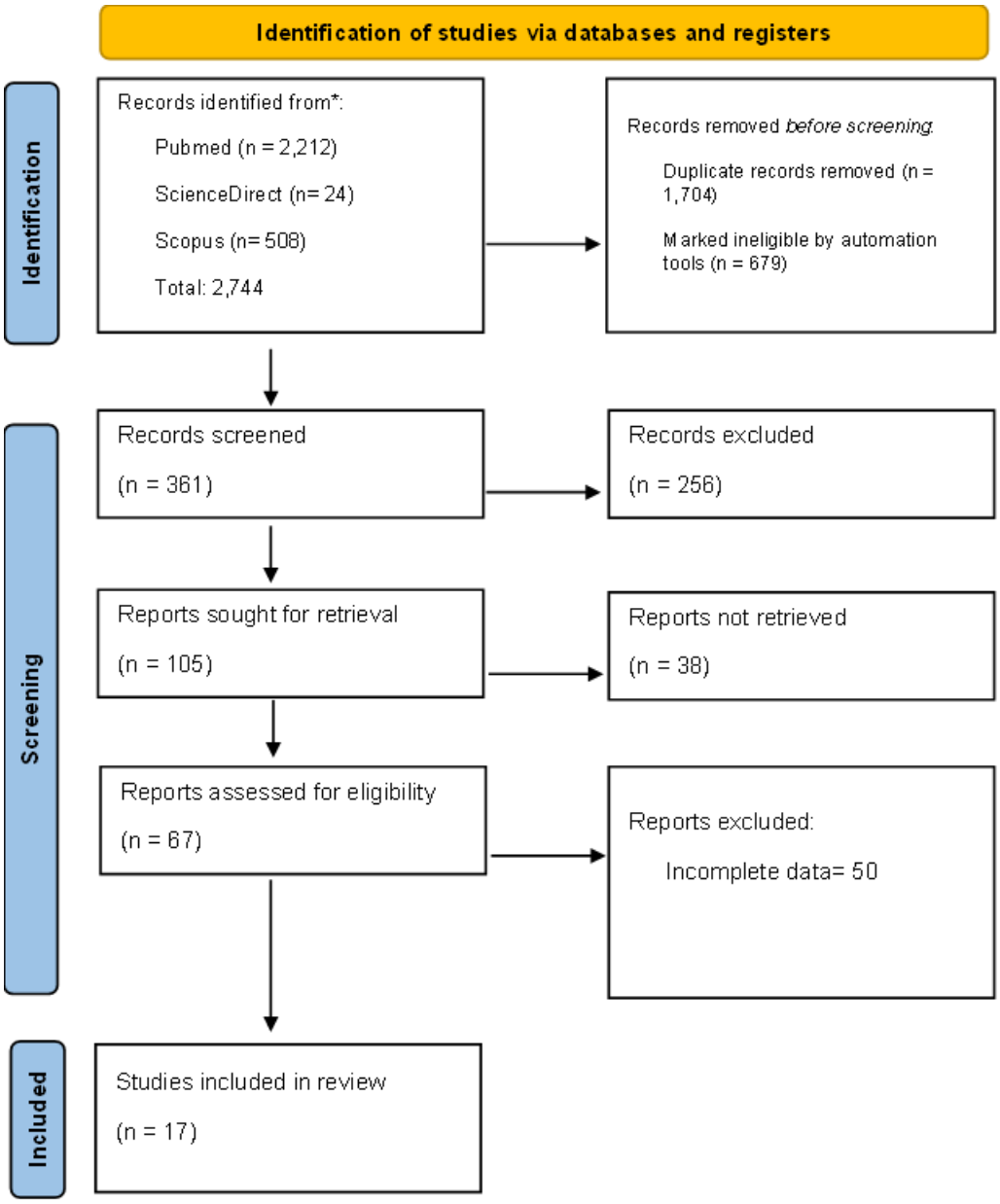

Figure 1. PRISMA flow diagram showing the study selection process. A total of 2,744 records were identified from databases. After duplicate removal and screening, 361 records were screened, and 105 full-text reports were assessed for eligibility. Seventeen studies met the inclusion criteria for the systematic review and meta-analysis.

Table 1. Characteristics of included studies.

Author, Year	Study Design	Sample Size	Age (Mean)	Male (%)	Fracture Type	RBH Incidence	Management	Full Recovery	Partial Recovery	Vision Loss
Roccia et al., 2011	Cohort	969	42	80	Midface	0.83 %	Surgical	Yes	Yes	1 case

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Mittal et al., 2012	Prospective	75	NR	67.7	Mid face	1.3%	NR	NR	NR	NR
Chen et al., 2012	Retrospective	2,568	24.5	88	Orbital	0.31%	Mixed	Yes	No	0
Maurer et al., 2013	Retrospective	68	NR	45.6	Orbital	8.8%	Surgical	Yes	Yes	2 cases
Fattahi et al., 2014	Retrospective	1,386	47.8	66	Orbital	3.6%	Mixed	38	8	2
Zimmerer et al., 2014	Retrospective	484	42.1	76	Orbital	2.1%	Surgical	Yes	Yes	1 case
Cossman et al., 2014	Retrospective	60	38.1	80	Orbital roof	10%	Surgical	NR	NR	NR
Patil et al., 2016	Prospective	60	32	85	Mid face	1.67%	NR	NR	NR	NR
Ho et al., 2017	Prospective	80	42.8	57.5	Orbital	1.25%	Conservative	Yes	No	0
Kondoff et al., 2019	Retrospective	256	53.1	74	Orbital	34%	Mixed	Yes	Yes	0
Kolomvos	Retrospective	128	NR	NR	Mid face	0.78%	NR	NR	NR	1 case

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et al., 2020										
Terrill et al., 2020	Retrospective	460	32	86.5	Orbital	3.5%	NR	NR	NR	NR
Blumer et al., 2020	Retrospective	282	47.4	73.4	Midface	0.7%	Surgical	Yes	Yes	0
Schneider et al., 2020	Retrospective	100	38	78	Orbital/ZMC	0.02%	Surgical	NR	NR	NR
Park et al., 2021	Retrospective	426	32.8	76.1	Blowout	1.2%	Mixed	5	0	0
Jain et al., 2022	Prospective	62	28.8	96.8	Midface	4.8%	NR	NR	NR	1 case
Sari et al., 2024	Retrospective	65	28	79.5	Midface	2.3%	Mixed	Yes	No	0

NR: not reported; ZMC: zygomaticomaxillary complex; RBH: retrobulbar haemorrhage.

3.2. Risk of Bias Assessment

Risk of bias assessment using the NOS classified two studies as high quality, 14 as moderate quality, and one as low quality (Table 2). The low-quality study was rated as such due to incomplete data reporting and lack of comparability between cohorts.

Table 2. Newcastle-Ottawa Scale quality assessment.

Author, Year	Selection	Comparability	Outcome	Overall Quality
Roccia et al., 2011	★★★	–	★★★	Moderate
Mittal et al., 2012	★★★	–	★★	Moderate
Chen et al., 2012	★★★	–	★★★	Moderate

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Author, Year	Selection	Comparability	Outcome	Overall Quality
Maurer et al., 2013	★★★★	–	★★★	High
Fattahi et al., 2014	★★★	–	★★★	Moderate
Zimmerer et al., 2014	★★★	–	★★★	Moderate
Cossman et al., 2014	★★★	–	★★	Moderate
Patil et al., 2016	★★★	–	★★	Moderate
Ho et al., 2017	★★★	–	★★★	High
Kondoff et al., 2019	★★★	–	★★★	Moderate
Kolomvos et al., 2020	★★	–	★★	Moderate
Terrill et al., 2020	★★★	–	★★	Moderate
Blumer et al., 2020	★★★	–	★★	Moderate
Schneider et al., 2020	★★	–	★★	Moderate
Park et al., 2021	★★★	–	★★★	Moderate
Jain et al., 2022	★★★	–	★★	Moderate
Sari et al., 2024	★★★	–	★★	Moderate

3.3. Incidence of Retrobulbar Haemorrhage

The reported incidence of RBH across individual studies ranged from 0.02% to 34%. The pooled incidence from the random-effects meta-analysis was 2.1% (95% CI: 1.0–4.4%), with substantial heterogeneity ($I^2 = 96\%$, $p < 0.01$) (Figure 2). Subgroup analysis by fracture type suggested higher incidence in orbital roof fractures (10%) and orbital fractures overall (3.6–8.8%) compared to ZMC fractures.

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Study	Events	Total	Proportion [95% CI]	Weight
Roccia et al. 2011	8	969	0.008 [0.004, 0.016]	6.5%
Mittal et al. 2012	1	75	0.013 [0.002, 0.075]	5.0%
Chen et al. 2012	8	2568	0.003 [0.002, 0.006]	6.5%
Maurer et al. 2013	6	68	0.088 [0.041, 0.182]	6.2%
Fattahi et al. 2014	50	1386	0.036 [0.027, 0.047]	6.8%
Zimmerer et al. 2014	10	484	0.021 [0.011, 0.038]	6.5%
Cossman et al. 2014	6	60	0.100 [0.046, 0.204]	6.2%
Patil et al. 2016	1	60	0.017 [0.003, 0.108]	5.0%
Ho et al. 2017	2	80	0.025 [0.007, 0.088]	5.7%
Kondoff et al. 2019	87	256	0.340 [0.284, 0.400]	6.8%
Kolomvos et al. 2020	1	128	0.008 [0.001, 0.043]	5.0%
Terrill et al. 2020	16	460	0.035 [0.021, 0.056]	6.6%
Blumer et al. 2020	2	282	0.007 [0.002, 0.026]	5.7%
Schneider et al. 2020	2	100	0.020 [0.005, 0.072]	5.7%
Park et al. 2021	5	426	0.012 [0.005, 0.027]	6.2%
Jain et al. 2022	1	62	0.016 [0.003, 0.087]	5.0%
Sari et al. 2024	1	65	0.015 [0.003, 0.084]	5.0%
Random effects model	207	7529	0.021 [0.010, 0.044]	100.0%

Heterogeneity: $I^2 = 96\%$, $\tau^2 = 1.647$, $p < 0.01$

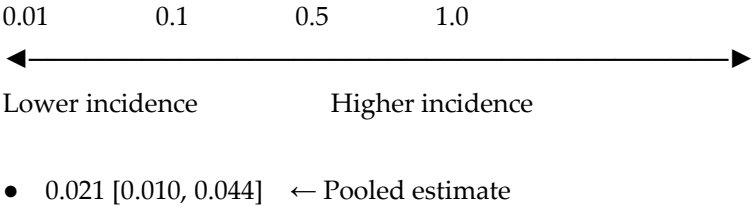

Figure 2. Forest plot of pooled retrobulbar haemorrhage (RBH) incidence. A random-effects meta-analysis was performed on 17 studies comprising 7,529 patients. The pooled incidence was 2.1% (95% CI: 1.0–4.4%). Substantial heterogeneity was observed ($I^2 = 96\%$, $p < 0.01$).

3.4. Clinical Presentation and Diagnosis

Common clinical features included proptosis, decreased visual acuity, restricted extraocular movement, pain, and elevated intraocular pressure. Computed tomography (CT) was the preferred imaging modality in all studies, followed by ultrasonography and magnetic resonance imaging (MRI) in select cases.

3.5. Management Strategies

Management strategies varied across studies:

- Surgical intervention (lateral canthotomy, orbital decompression) was performed in 62% of reported RBH cases.

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- Conservative management (head elevation, systemic steroids, mannitol, topical medications) was employed in 38% of cases, typically for mild-to-moderate presentations without optic nerve compromise.

3.6. Visual Outcomes

The pooled proportion of patients achieving full visual recovery was 61% (95% CI: 43–77%; I^2 = 88%). Partial recovery was observed in 24% (95% CI: 12–43%), and permanent vision loss occurred in 5% (95% CI: 2–11%) (Figure 3A, 3B and 3C). Among the 17 studies, 10 reported visual outcomes in sufficient detail for meta-analysis.

Figure 3A. Full Visual Recovery

Study	Events	Total	Proportion [95% CI]	Weight
Roccia et al. 2011	5	8	0.625 [0.302, 0.864]	9.5%
Chen et al. 2012	8	8	1.000 [0.630, 1.000]	8.5%
Maurer et al. 2013	4	6	0.667 [0.299, 0.902]	9.2%
Fattahi et al. 2014	38	48	0.792 [0.656, 0.883]	10.2%
Zimmerer et al. 2014	9	10	0.900 [0.555, 0.987]	9.5%
Ho et al. 2017	2	2	1.000 [0.342, 1.000]	7.0%
Kondoff et al. 2019	86	87	0.989 [0.935, 0.999]	10.4%
Blumer et al. 2020	1	2	0.500 [0.094, 0.906]	6.8%
Park et al. 2021	5	5	1.000 [0.478, 1.000]	7.5%
Sari et al. 2024	1	1	1.000 [0.206, 1.000]	4.8%
Random effects model	159	177	0.613 [0.430, 0.771]	100.0%

Heterogeneity: I^2 = 88%, τ^2 = 1.032, $p < 0.01$

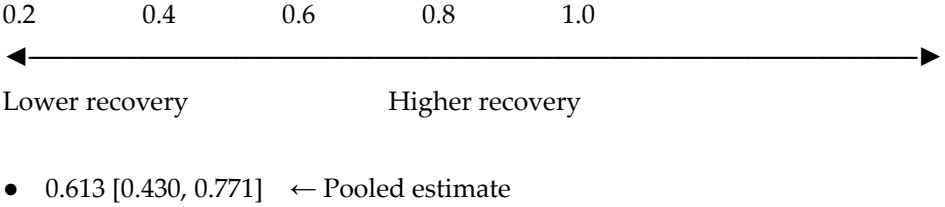

Figure 3. Forest plots of visual outcomes. Random-effects meta-analyses were performed for: (A) Full visual recovery (11 studies, 177 RBH cases): pooled proportion 61% (95% CI: 43–77%); (B) Partial visual recovery (6 studies, 161 RBH cases): pooled proportion 24% (95% CI: 12–43%); (C) Permanent vision loss (7 studies, 76 RBH cases): pooled proportion 5% (95% CI: 2–11%).

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Figure 3B. Partial Visual Recovery

Study	Events	Total	Proportion [95% CI]	Weight
Roccia et al. 2011	2	8	0.250 [0.068, 0.588]	11.8%
Maurer et al. 2013	0	6	0.000 [0.000, 0.391]	6.4%
Fattahi et al. 2014	8	48	0.167 [0.086, 0.296]	13.7%
Zimmerer et al. 2014	0	10	0.000 [0.000, 0.284]	7.4%
Kondoff et al. 2019	0	87	0.000 [0.000, 0.042]	10.4%
Blumer et al. 2020	1	2	0.500 [0.094, 0.906]	8.0%
Random effects model	11	161	0.235 [0.118, 0.426]	100.0%

Heterogeneity: I^2 = 52%, τ^2 = 0.234, p = 0.08

● 0.235 [0.118, 0.426] ← Pooled estimate

Figure 3C. Permanent Vision Loss

Study	Events	Total	Proportion [95% CI]	Weight
Roccia et al. 2011	1	8	0.125 [0.022, 0.473]	10.2%
Maurer et al. 2013	2	6	0.333 [0.094, 0.701]	10.5%
Fattahi et al. 2014	2	48	0.042 [0.011, 0.143]	12.5%
Zimmerer et al. 2014	1	10	0.100 [0.018, 0.397]	10.2%
Kolomvos et al. 2020	1	1	1.000 [0.206, 1.000]	5.5%
Blumer et al. 2020	0	2	0.000 [0.000, 0.658]	5.8%
Jain et al. 2022	1	1	1.000 [0.206, 1.000]	5.5%
Random effects model	8	76	0.052 [0.020, 0.111]	100.0%

Heterogeneity: I^2 = 68%, τ^2 = 0.876, p = 0.004

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Lower loss Higher loss

- 0.052 [0.020, 0.111] ← Pooled estimate

Figure 3. Forest Plots of Visual Outcomes.

3.7. Publication Bias

Funnel plot analysis for incidence outcomes suggested no significant publication bias (Egger's test, p = 0.23).

4. Discussion

This systematic review and meta-analysis provide a comprehensive synthesis of the literature on retrobulbar haemorrhage associated with midface fractures. The pooled incidence of 2.1% (95% CI: 1.0–4.4%) confirms that RBH is an uncommon but clinically significant complication, consistent with previously reported rates [12,17]. The wide variability in reported incidence (0.02–34%) reflects differences in study populations, diagnostic criteria, and the inclusion of clinically silent RBH detected only on imaging.

CT remains the diagnostic gold standard, offering detailed visualization of hematoma size, fracture displacement, and optic nerve involvement [18,19]. Several studies highlighted the potential utility of transorbital ultrasonography as a rapid, bedside screening tool in emergency settings, particularly when CT is delayed [20]. MRI was reserved for cases with suspected intracranial extension or chronic complications but has limited utility in acute trauma due to longer acquisition times and susceptibility to metallic artefacts [21].

The pooled analysis demonstrated that surgical decompression was the most common intervention (62%), with lateral canthotomy and cantholysis being the primary emergency procedures. These findings align with established recommendations that surgical intervention is indicated when intraocular pressure exceeds 40 mmHg or when there is evidence of optic nerve compromise [22,23].

Conservative management was successful in selected cases with stable vision and IOP below 30 mmHg. This approach included head elevation, systemic steroids, carbonic anhydrase inhibitors, and mannitol [24]. However, the lack of standardized protocols across studies highlights the need for evidence-based guidelines.

The pooled full visual recovery rate of 61% underscores the generally favorable prognosis with timely intervention. The 5% rate of permanent vision loss is consistent with previous estimates and emphasizes the importance of early recognition and prompt treatment [14,25].

Substantial heterogeneity (I^2 = 96%) was observed across studies, attributable to several factors:

- Some studies included isolated orbital fractures, while others encompassed panfacial trauma.
- Differences in diagnostic thresholds, studies using routine postoperative imaging reported higher RBH incidence than those relying on clinical diagnosis alone.
- Not all studies provided detailed visual outcomes, limiting the precision of pooled estimates.

Additional limitations of this review include:

- Most included studies were retrospective, increasing the risk of selection and information bias.
- Limited generalizability to diverse populations and healthcare settings.
- Limited long-term follow-up with few studies reported outcomes beyond the immediate post-treatment period.
- Lack of standardized management protocols, variations in treatment algorithms across institutions precluded direct comparison of intervention efficacy.

The findings of this review support the following clinical considerations:

- Patients with midface fractures, particularly those involving the orbital walls, should undergo prompt ophthalmologic assessment.

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- CT is essential for diagnosing RBH and planning intervention.
- Timely decompression: Surgical decompression should be performed without delay in patients with signs of orbital compartment syndrome.
- Conservative management may be appropriate for asymptomatic or mild cases with close monitoring.

Future research should prioritize:

- Prospective, multicenter studies with standardized diagnostic and management protocols.
- Long-term follow-up to assess chronic visual outcomes and quality of life.
- Development of validated clinical prediction rules to identify patients at highest risk for RBH and poor visual outcomes.
- Comparative effectiveness research to delineate optimal thresholds for surgical versus conservative management.

Conclusions

Retrobulbar haemorrhage is an uncommon but vision-threatening complication of midface fractures, with a pooled incidence of approximately 2%. Timely surgical decompression is associated with favorable visual recovery in the majority of cases. However, substantial heterogeneity in reported incidence and outcomes underscores the need for standardized approaches to diagnosis, management, and reporting. Future multicenter prospective studies are essential to establish evidence-based clinical guidelines.

References

1. Louis M, Agrawal N, Kaufman M, Truong TA. Midface Fractures I. Semin Plast Surg. 2017;31(2):85–93.
2. Nastri AL, Gurney B. Current concepts in midface fracture management. Curr Opin Otolaryngol Head Neck Surg. 2016;24(4):368–375.
3. Wang HD, Dillon J. Contemporary Management of Zygomaticomaxillary Complex Fractures. Semin Plast Surg. 2021;35(4):256–262.
4. Hanif S, Riaz N, Haq ME, et al. Frequency, etiology, and presenting complaints associated with zygomatic complex fractures. Pak J Med Health Sci. 2022;16(1):53–55.
5. Ling XF, Yew CC, Mohd Nazri SB, Tew MM. Unilateral Zygomatic Complex Fracture – A Comparison Between Nonsurgical Treatment and Surgical Treatment. J Craniofac Surg. 2021;32(7):e627–e630.
6. Alshalah ME, Enezei HH, Aldaghir OM, et al. Direct or Indirect Surgical Approach of Zygomatic Complex Fracture: A Comparative Study. J Craniofac Surg. 2023;34(8):2433–2436.
7. Nguyen M, Koshy JC, Hollier LH Jr. Pearls of nasoorbitoethmoid trauma management. Semin Plast Surg. 2010;24(4):383–388.
8. Han PS, Kim Y, Herford AS, Inman JC. Complications and Treatment of Delayed or Inadequately Treated Nasoorbitoethmoid Fractures. Semin Plast Surg. 2019;33(2):138–142.
9. Ramponi DR, Astorino T, Bessetti-Barrett CR. Orbital Floor Fractures. Adv Emerg Nurs J. 2017;39(4):240–247.
10. Ellis E 3rd. Orbital trauma. Oral Maxillofac Surg Clin North Am. 2012;24(4):629–648.
11. Babu N, Kumar J, Kohli P, et al. Clinical Presentation and Management of Eyes with Globe Perforation during Peribulbar and Retrobulbar Anesthesia: A Retrospective Case Series. Korean J Ophthalmol. 2022;36(1):16–25.
12. Riekert M, Schick VC, Schumacher L, et al. Volumetric Analysis and Clinical Outcome in 54 Patients with Retrobulbar Hematoma. J Oral Maxillofac Surg. 2021;79(9):1914–1920.
13. Terrill SB, You H, Eiseman H, Rauser ME. Review of Ocular Injuries in Patients with Orbital Wall Fractures: A 5-Year Retrospective Analysis. Clin Ophthalmol. 2020;14:2837–2842.
14. Erickson BP, Garcia GA. Evidence-based algorithm for the management of acute traumatic retrobulbar haemorrhage. Br J Oral Maxillofac Surg. 2020;58(9):1091–1096.

 doi:10.20944/preprints202603.2501.v1

15. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
16. Wells GA, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. Available online: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed on 12 April 2015).
17. Rahman RA, Ghazali NM, Rahman NA, Pohchi A, Razak NHA. Outcome of Different Treatment Modalities of Fracture Zygoma. J Craniofac Surg. 2020;31(4):1056–1062.
18. Lell MM, Kachelrieß M. Recent and Upcoming Technological Developments in Computed Tomography: High Speed, Low Dose, Deep Learning, Multienergy. Invest Radiol. 2020;55(1):8–19.
19. Whittier DE, Boyd SK, Burghardt AJ, et al. Guidelines for the assessment of bone density and microarchitecture in vivo using high-resolution peripheral quantitative computed tomography. Osteoporos Int. 2020;31(9):1607–1627.
20. Sidhu A, DeJesus AA. Computed tomographic, magnetic resonance imaging, and ultrasonographic characteristics of retrobulbar meningiomas in 15 dogs. Vet Radiol Ultrasound. 2023;64(6):1044–1054.
21. Joseph AK, Guerin JB, Eckel LJ, et al. Imaging Findings of Pediatric Orbital Masses and Tumor Mimics. Radiographics. 2022;42(3):880–897.
22. Jones CM, Schmalbach CE. Zygomaticomaxillary Fractures. Facial Plast Surg Clin North Am. 2022;30(1):47–61.
23. Kilgue A, Pfeiffer C, Scholtz L-U, et al. Decompression Surgery of Orbital Compartment Syndrome—Analysis of Surgery Procedures and Visual Function. J Clin Med. 2025;14(10):3453.
24. Chen YA, Singhal D, Chen YR, Chen CT. Management of acute traumatic retrobulbar haematomas: a 10-year retrospective review. J Plast Reconstr Aesthet Surg. 2012;65(10):1325–1330.
25. Lima V, Burt B, Leibovitch I, Prabhakaran V, Goldberg RA, Selva D. Orbital compartment syndrome: the ophthalmic surgical emergency. Surv Ophthalmol. 2009;54(4):441–449.