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ADVANCES IN SURGICAL RECONSTRUCTION OF ISOLATED MEDIAL ORBITAL WALL FRACTURES

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Abstract

Isolated medial orbital wall fractures remain a small but technically demanding subset of orbital trauma. The deep location of the defect, the thin lamina papyracea, the risk of medial rectus entrapment, and the challenge of securing posterior support have kept reconstruction strategy under debate even as imaging, implants, and navigation have improved. A focused narrative review was prepared with emphasis on studies from the last decade that directly addressed isolated medial orbital wall fractures or offered closely transferable data on orbital reconstruction technology, implant positioning, and revision. Priority was given to systematic reviews, comparative studies, large case series, and technique papers reporting indications, access route, reconstruction method, implant choice, orbital volume restoration, diplopia, enophthalmos, motility, complications, and reintervention. Recent literature shows a clear shift from simple defect coverage toward anatomy-driven reconstruction. Transcaruncular and retrocaruncular exposure remain the main direct routes because they combine scar avoidance with reliable access to the medial wall. Endoscopic endonasal repair has matured from a niche alternative into a reproducible minimally invasive option with strong functional results in selected cases. A 2025 systematic review of 204 patients reported improvement or resolution of diplopia in 98.1 percent, enophthalmos in 88.2 percent, and motility restriction in 100 percent, with no reported revision surgery. Comparative and technical series also support newer repositioning methods, endoscopic slide-in reconstruction, and hybrid transcaruncular plus transethmoidal approaches. Material selection has become more tailored than dogmatic. Porous polyethylene, absorbable meshes, titanium devices, and u-HA and PLLA composites each have a defensible role when matched to defect geometry and the need for structural support. Digital tools are increasingly important in the deep posterior orbit, where free-hand reconstruction is most vulnerable to error. Navigation improves volumetric accuracy and lowers revision in broader orbital reconstruction, and medial-wall-specific data now show better orbital volume correction with navigation than without it. The major advances in medial wall reconstruction are not simply new implants. They are better control of the posterior boundary of the defect, safer minimally invasive access, and more accurate restoration of orbital volume. The field is moving toward selective endoscopic repair, navigation-guided reconstruction, and defect-matched biomaterials, but the evidence base remains dominated by retrospective series rather than high-level comparative trials.

Keywords

medial orbital wall fracture, orbital reconstruction, transcaruncular approach, endoscopic endonasal repair, surgical navigation, orbital implants, enophthalmos, diplopia

Introduction

The medial orbital wall sits at an awkward junction of fragility and consequence. Its thin bony shell fractures easily, yet the defect extends into a deep corridor where visualization worsens, the optic canal lies close behind, and small errors in implant placement can translate into persistent diplopia, enophthalmos, or revision surgery [1], [3], [17], [30]. For that reason, medial wall fractures have long been managed by a mix of observation, delayed intervention, and several competing reconstructive techniques.

Over the last decade, the center of gravity has shifted. The literature is no longer focused only on whether to operate. It increasingly asks how to reconstruct the deep medial orbit more precisely, how to restore volume without overstuffing the ethmoid side, and how to reduce posterior malposition that escapes direct view during conventional surgery [7], [11], [15], [16]. At the same time, endoscopic endonasal surgery has expanded, absorbable materials have improved, and patient-specific planning has influenced orbital surgery more broadly [4], [6], [18].

A contemporary review should therefore treat isolated medial wall fractures as a reconstructive problem rather than a narrow access problem. The key issue is not only reaching the defect. It is rebuilding a thin, curved wall in a confined space while preserving motility and globe position.

Materials and Methods

This article is a focused narrative review of contemporary surgical reconstruction for isolated medial orbital wall fractures. The synthesis emphasizes literature published from 2015 onward. Older landmark concepts were retained when they remained central to current practice.

Studies were prioritized when they met at least one of the following criteria:

- They focused specifically on isolated medial orbital wall fractures [2], [3], [4], [11], [14], [19]
- They described a defined medial wall technique with clinical outcomes [8], [9], [10], [15], [16], [20], [21]
- They provided high-value transferable evidence on access, biomaterials, navigation, intraoperative imaging, or revision in orbital reconstruction [5], [6], [7], [12], [13], [17]

The main outcomes extracted were surgical indications, timing, access route, reconstruction concept, implant choice, orbital volume restoration, diplopia, extraocular motility, globe position, complications, and reintervention. Because the aim was a clinically usable review rather than a new formal meta-analysis, pooled estimates were reported only when they were available from the source studies themselves.

Results

Evidence base and main themes

The recent literature is broad but uneven. The strongest high-level summaries are recent reviews on isolated medial wall fractures and endoscopic repair [2], [4]. Much of the technical detail still comes from retrospective case series, often single center and surgeon dependent [3], [8], [11]. Across these studies, five themes recur:

- Surgery remains indication-driven rather than routine
- Transcaruncular exposure remains the default direct route
- Endoscopic endonasal repair is increasingly credible for selected defects
- Material choice matters less than accurate posterior support and volume restoration
- Technology is most useful where anatomy is least forgiving, namely the deep posterior orbit

Study	Design and cohort	Focus	Main finding
[2]	Review of 55 papers, 738 surgical and 214 conservative patients	Isolated medial wall management	Postoperative courses were broadly similar across groups, but surgically treated patients presented with more severe findings, especially medial rectus involvement

Study	Design and cohort	Focus	Main finding
[4]	Systematic review, 6 studies, 204 patients	Endoscopic endonasal repair	Diplopia improved or resolved in 98.1 percent, enophthalmos in 88.2 percent, motility restriction in 100 percent, with no reported revision surgery
[3]	Comparative cohort, 48 isolated fractures	Navigation-guided hybrid repair	Navigation improved orbital volume ratio reduction, 4.23 percent versus 2.57 percent
[11]	Retrospective comparison, 40 isolated fractures	Endoscopic slide-in versus transcaruncular repair	Similar clinical correction with shorter operating time for endoscopy, 44.7 versus 73.9 minutes
[14]	Retrospective cohort, 302 isolated fractures	Porous polyethylene versus absorbable mesh	Early postoperative prominence differed, but long-term enophthalmos and diplopia were comparable
[8]	Anatomical and clinical study, 174 repairs, 33 pure medial	Retrocaruncular access	Broad medial exposure with low complication burden and marked improvement in enophthalmos and motility
[16]	Retrospective series, 18 repairs	Titanium mesh with conventional, endoscopic, or navigation assistance	Posterior seating failures clustered in free-hand cases and drove the only reoperations

Indications and timing

The modern literature does not support a one-size-fits-all operative policy. Recent reviews show that asymptomatic or minimally symptomatic isolated medial wall fractures can often be observed, whereas persistent diplopia, motility restriction, clinically meaningful enophthalmos, large defects with expected volume change, and especially medial rectus entrapment remain the clearest triggers for repair [1], [2], [19].

The best-supported urgent indication is entrapment. Medial rectus incarceration is uncommon but important because it can present with marked abduction deficit, straight-gaze diplopia, and sometimes an oculocardiac reflex. A recent pooled analysis found full recovery in only 62.1 percent of reported cases, with 37.9 percent having some residual diplopia at longest follow-up, which underscores the cost of delayed release [22].

Timing remains more evidence-based in broader orbital trauma than in medial wall fractures alone, but the overall direction is consistent. When surgery is indicated, earlier repair is generally favored before fibrosis fixes the soft tissues in a displaced position [1], [23], [24]. Kim and colleagues recommended repair within two weeks for extensive fractures with anticipated enophthalmos [1]. Endoscopic series also reflect this practice pattern, with mean time to surgery of 13.2 days in a 131-patient series [21].

Evolution of surgical access

Transcaruncular and retrocaruncular routes remain the workhorse approaches because they offer direct access without a skin incision. The deeper value of these routes is not only cosmesis. They provide an efficient line to the medial wall while protecting the medial canthal tendon and lacrimal apparatus when the correct plane is respected [1], [8], [9]. In the anatomical and clinical study by Shen and colleagues, a retrocaruncular incision exposed the full medial wall and key landmarks, including the ethmoidal neurovascular bundles and inferonasal strut. In the acute subgroup, enophthalmos fell from 34 percent preoperatively to 4 percent after surgery, while extraocular motility deficits fell from 41 percent to 11 percent, with only three notable complications in 174 patients [8].

The transcaruncular route also lends itself to extension and hybridization. It can be coupled to transconjunctival access for larger combined defects, or combined with a transethmoidal maneuver to support fragment reduction from the sinus side [3], [9]. This adaptability helps explain why transcaruncular access remains dominant even as endoscopic surgery grows.

Endoscopic endonasal repair is the clearest procedural advance of the last decade. Early concern centered on limited implant handling and the technical difficulty of reconstruction within the ethmoid corridor [1]. More recent evidence suggests those limitations are becoming more manageable in selected cases. The systematic review by Ruthberg and colleagues found high rates of symptom resolution across six studies and no reported revision surgery [4]. Bonsembiante and colleagues showed that endonasal reduction can be paired with autologous or alloplastic reconstruction and temporary nasal support, with no late complications in their small series [20]. Kim and colleagues then described an endoscopic slide-in method that places porous polyethylene within the orbit rather than the sinus, shortening operating time while maintaining outcome quality in comparison with transcaruncular repair [11].

The approach question is therefore no longer transcaruncular or endoscopic in absolute terms. The better reading of the literature is that each route solves a different reconstructive problem. Transcaruncular access is generally stronger for controlled implant placement and direct work on the orbital side of the defect. Endoscopy is attractive when minimal invasiveness and ethmoidal support are priorities, especially for reducible isolated fractures without complex comminution [4], [11], [20]. Broader comparative data across orbital fractures support the favorable safety profile of transcaruncular access. In a systematic review of 1137 fractures, the transcaruncular approach had a 14.0 percent complication rate, lower than endoscopic repair at 20.2 percent and far lower than transconjunctival repair at 36.2 percent, although between-study heterogeneity limits direct ranking [5].

Reconstruction concepts

A useful conceptual contribution from the medial wall literature is that techniques can be grouped by what they try to restore rather than by incision alone. Kim and colleagues described three broad reconstruction concepts: onlay covering, inlay implantation, and repositioning of the native wall [1]. That framework remains clinically useful.

Onlay repair is the familiar strategy of reducing the herniated tissue and covering the defect from the orbital side with a thin implant. It is versatile and widely used, but it depends on reliable seating along the defect margins. In the medial orbit, the weak point is usually posterior, where incomplete support can allow the implant to hinge, sink, or sit short of the true ledge [1], [16], [17].

Inlay methods place material within the ethmoid sinus to buttress the defect from behind. They are attractive when the bony edges are fragmented or when posterior access from the orbital side is unsafe. The tradeoff is that support may be less predictable if the material shifts or if packing is not maintained long enough [1], [21].

Repositioning methods aim to preserve and lateralize the native fractured segment instead of replacing it with a large implant. The push-out technique reported by Kim and colleagues is the clearest example. In 16 patients, this method improved orbital volume and Hertel measurements while limiting subperiosteal dissection around the fracture. Its value seems greatest in large single-segment fractures and selected old fractures with preserved sinus mucosa, but it is poorly suited to comminution or soft tissue entrapment [10].

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A related endoscopic evolution is the slide-in technique, which uses endonasal access to place the implant into the orbit in a posterior-to-anterior sequence. This preserves the advantages of endoscopy while acknowledging that true orbital side support is often more stable than pure sinus packing [11]. The direction of innovation is therefore not random. It repeatedly moves toward better control of posterior support while reducing unnecessary dissection.

Biomaterials and implant strategy

No single material has displaced all others. The modern literature instead supports defect-matched material selection.

Material	Typical role in medial wall repair	Advantages	Main concerns
Porous polyethylene	Onlay or layered inlay support for small to moderate isolated defects [1], [14]	Biocompatible, tissue ingrowth, easy contouring	Can be insufficient for large unstable defects if posterior support is poor
Absorbable mesh or plate	Barrier support for isolated medial wall defects with preserved buttresses [3], [13], [14]	No permanent hardware, good handling, useful in thin-walled orbit	Less rigid, risk of malposition or delayed contour loss if poorly seated [25]
Titanium mesh or preformed titanium plate	Larger defects, difficult geometry, cases needing rigid contour control [12], [16]	Strong posterior support, stable shape, good for complex contour	Higher cost, sharper edges, placement error can be consequential
u-HA and PLLA composite	Navigation-assisted medial wall reconstruction [15]	Osteoconductive concept, moldable, suitable for thin wall contour	Limited evidence, mainly small case series

Two material messages are fairly consistent. First, isolated medial wall fractures do not always need rigid load-bearing implants. Resorbable devices can perform well when the surrounding buttresses are intact and the reconstruction functions mainly as a barrier rather than a structural beam [13]. Second, the border between a successful light implant and a failed one is usually technical rather than chemical. In a 302-patient cohort, absorbable poly L and DL lactide mesh and porous polyethylene produced comparable long-term enophthalmos and diplopia outcomes after isolated medial wall repair, despite some early postoperative differences [14]. That result suggests that implant positioning and case selection may matter more than material ideology.

Still, material-specific failure modes deserve attention. Hwang and Ma reported reoperation for malposition of resorbable sheets in medial wall fractures and proposed a preventive strategy based on L-shaped contouring, inferomedial angle control, fixation at the rim, and a tension-free forced duction test before closure [25]. At the other end of the rigidity spectrum, titanium devices offer strong geometric support but can still fail if they do not reach the posterior boundary accurately [16], [17].

Navigation, virtual planning, and imaging

Digital assistance is one of the most meaningful advances in this field because it addresses the main anatomical blind spot of medial wall surgery. In the study by Gerbino and colleagues, conventional free-hand titanium mesh placement failed to reach the posterior ledge in four of seven cases. That problem disappeared in the endoscopy-assisted group and was reduced to one case in the navigation group. The only reoperations occurred after conventional repair [16].

The same pattern appears in more recent isolated-medial-wall data. Jeon and colleagues compared 23 navigation-guided cases with 25 non-navigation cases using a combined transcaruncular and transethmoidal technique with a resorbable plate and Nasopore support. Both groups improved clinically, but the navigation group achieved greater reduction in orbital volume ratio, 4.23 percent versus 2.57 percent, with no residual symptoms or complications [3]. Dong and colleagues also reported that navigation-assisted reconstruction with a u-HA and PLLA sheet restored postoperative orbital volume to that of the unaffected side in a 10-patient series [15].

This medial-wall-specific evidence fits a broader orbital trend. A 2024 systematic review found that virtual planning was used in 91.6 percent of technology-guided orbital trauma studies and that the most common combination was virtual planning plus navigation, used in 75 percent [6]. A 2023 meta-analysis of patient-specific orbital reconstruction showed significantly better volumetric accuracy with navigation, about 0.93 cm3 compared with 2.17 cm3 for conventional surgery, and a lower revision rate, 4.9 percent versus 17 percent, albeit at higher cost [7]. Even though those data are not restricted to isolated medial wall fractures, they are highly relevant because the posterior medial orbit is exactly where conventional free-hand judgment is least dependable.

Intraoperative imaging appears to work by the same principle. Systematic reviews suggest that intraoperative computed tomography can detect misplacement early and likely reduce avoidable revision, although the evidence is heterogeneous and more robust for complex orbital trauma than for pure medial wall defects [26], [27].

Endoscopic support and postoperative stabilization

One practical lesson from recent endoscopic series is that reconstruction does not end when the herniated tissue is reduced. Medial wall repair often depends on

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temporary support inside the ethmoid sinus until the reduced tissues and reconstructed wall stabilize. Kim and colleagues described a simple packing method using Merocel within a glove finger after endoscopic endonasal reduction in 131 patients. Mean operating time was 34.1 minutes, postoperative computed tomography showed no re-bulging at three months, and only three patients had persistent diplopia while one had persistent enophthalmos at final follow-up. There was one case of symptomatic frontal sinusitis and no major postoperative complications [21].

This series is important because it translates the appeal of endoscopy into a reproducible maintenance strategy. The point is not that a glove-covered pack is universally superior. The point is that endoscopic medial wall repair succeeds when reduction, support, and removal are designed as one workflow rather than as separate improvisations.

Outcomes, complications, and revision patterns

The surgical literature for isolated medial wall fractures is generally favorable. Most series report high rates of symptom improvement, low rates of severe complications, and better restoration of orbital volume than would be expected with observation in clearly operative cases [2], [3], [4], [15]. Yet the success story has an important caveat. Failures are usually not random. They cluster around posterior malposition, undercoverage of the deep defect, and residual volume expansion.

This is most clearly shown in revision data. Persson and colleagues found that 13 percent of orbital fracture patients required reintervention within one month, almost always because of implant malposition. Without exception, implant incongruence was found in the posterior orbit. Secondary reconstruction improved some patients, but none became completely free of both enophthalmos and diplopia after revision for these problems [17]. Although this series was not limited to isolated medial wall fractures, the message is directly applicable because the posterior medial orbit is one of the hardest regions to reconstruct accurately.

The same warning appears in medial-wall-specific technical papers. Conventional free-hand mesh placement performed worst when the posterior ledge was not visualized or verified [16]. Resorbable sheets may fail when they crumple or sit at the wrong angle [25]. Repositioning techniques can injure or irritate the medial rectus if small comminuted fragments are missed [10]. In other words, the modern complication profile is less about infection or exposure than about geometric error.

Discussion

The strongest conclusion from the recent literature is that advances in isolated medial wall reconstruction are converging on a simple principle: accurate restoration of the posterior contour matters more than the choice of a fashionable implant. Surgical progress has occurred along three linked axes.

First, access has become more selective. Transcaruncular and retrocaruncular routes remain highly effective because they offer direct and cosmetically acceptable entry into the medial orbit [8], [9]. Endoscopic endonasal surgery is no longer just an alternative for enthusiasts. In carefully selected isolated fractures, it can deliver excellent functional outcomes and shorter operating times, especially when paired with deliberate postoperative support [4], [11], [21].

Second, reconstruction concepts have become more anatomy-driven. Surgeons now choose between covering, buttressing, or repositioning the wall based on fracture shape, comminution, tissue entrapment, and the availability of reliable posterior support [1], [10]. This marks a real shift away from a one-implant-fits-all approach.

Third, technology has changed the deep orbit from a largely tactile problem into a measurable one. Navigation, virtual planning, and selective intraoperative imaging reduce uncertainty where human depth judgment is weakest [3], [7], [16]. Their greatest value is probably not routine use in every small defect. It is prevention of posterior misplacement in cases where the defect is deep, the contour is complex, or the consequences of error are high.

The evidence, however, remains limited in ways that matter for publication and for practice. Most reports are retrospective case series. Definitions of diplopia, enophthalmos, defect size, and radiologic success vary widely [5], [6]. Isolated medial wall fractures are often mixed with inferomedial or two-wall injuries, which makes direct comparison harder [28], [29]. The field still lacks high-quality head-to-head studies that compare transcaruncular, endoscopic, and navigation-assisted strategies within clearly defined medial-wall phenotypes.

A reasonable current treatment model emerges despite these weaknesses. Observation remains appropriate for many minimally symptomatic injuries. Surgery should be prompt for entrapment and early for patients with persistent diplopia, motility restriction, or meaningful volume-related globe displacement [1], [2], [22]. For reconstruction, transcaruncular access remains the dependable baseline approach. Endoscopic repair is a strong option for reducible isolated fractures in experienced hands. Absorbable implants and porous polyethylene are both acceptable for selected defects with preserved support, while rigid titanium and navigation gain value as defect depth, uncertainty, and posterior risk increase [3], [13], [14], [15].

Conclusion

Isolated medial orbital wall fracture repair has moved beyond simple defect closure. The modern reconstructive goal is precise restoration of orbital contour and volume, especially at the posterior extent of the defect. Transcaruncular access remains the standard direct route, endoscopic endonasal repair has become a mature minimally invasive alternative, and navigation-assisted reconstruction is increasingly persuasive for deep or high-risk defects [3], [4]. Material choice should be matched to geometry and support requirements rather than to dogma alone [12], [13], [14]. The next step for the field is not another small technical series. It is better comparative evidence that links fracture pattern, reconstructive method, volumetric correction, and long-term functional outcome.

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