A Systematic Review of the Endoscopic Management of Orbital Floor Fractures

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Objective: To determine the safety and efficacy of the endoscopic management of isolated orbital floor fractures.

Methods: A systematic review was performed using electronic databases. Studies investigating the reconstruction of isolated orbital floor fractures using an endoscopic approach were considered for inclusion. Two investigators independently reviewed all results. Study quality was assessed using the Methodological Index for Nonrandomized Studies scale. Primary outcomes were the resolution of diplopia and enophthalmos. Secondary outcomes were postoperative complications, including blindness, paresthesias, sinusitis, infection, conversion to external approach, and need for revision surgery.

Results: Nine studies capturing 172 patients met the inclusion criteria for systematic review. Two studies were comparative and 7 were case series. Study quality was poor, lacking prospective data and reliable assessment of outcomes. Strong reviewer agreement was observed (intraclass correlation, 84%; 95% CI, 35%-96%). Diplopia resolved in 102 of 118 patients (86%) and enophthalmos resolved in 41 of 43 (95%). No complications of blindness, sinusitis, or conversion to external approach were reported. Thirteen patients (8%) had transient cheek numbness. Two patients (1%) required revision surgery.

Conclusions: Reconstruction of isolated orbital floor fractures through an endoscopic approach appears to be safe and effective. High-level evidence prospectively comparing endoscopic and external approaches, however, is lacking.


Fractures of the orbital floor often result from blunt trauma associated with motor vehicle collisions, assault, or sports injury. Surgical reconstruction of isolated orbital floor fractures is commonly indicated for clinical entrapment, persistent diplopia, reflex bradycardia, and clinical enophthalmos. Large defects may also warrant surgical reconstruction, although debate exists regarding the optimal threshold for intervention. Traditional open reduction and orbital floor reconstruction usually involves an external approach through a subciliary, transconjunctival, or subtarsal incision. Risks associated with orbital floor reconstruction through an external skin incision are not negligible and include ecchymosis (3%-42%) and external scar.1 Following reduction of orbital contents, the floor is reconstructed with a rigid implant (eg, titanium plate or high-density polyethylene). Proper positioning of the implant requires an adequate posterior shelf for the implant to rest on. Management of fractures with a significant posterior shelf defect consequently can be challenging and time consuming.

Endoscopic sinus surgery is a safe and effective procedure routinely performed by otolaryngologists for the access and management of sinonasal pathology. Endoscopic sinus surgery enables excellent access to the maxillary sinus and direct visualization of the orbital floor through a maxillary antrostomy. Both endonasal and transantral (through a gingivobuccal incision and Caldwell-Luc antrostomy) approaches to the maxillary sinus have been described.2,3 Although this is not a novel concept, advances in endoscopic technology (improvement in illumination and image transmission) have allowed for excellent visibility and a higher-definition picture. Following assessment of the defect from below, herniating orbital fat and muscle can be gently reduced with an instrument. Reconstruction of the orbital floor can then be performed under direct visualization. Numerous techniques and implant materials have been described.4 Direct visualization of the orbital floor may reduce the risk of improper implant positioning previously encountered with nonendoscopic transantral approaches.5 Furthermore, in patients with a significant posterior orbital floor defect, recon-
struction through endoscopic sinus surgery may be advantageous, minimizing orbital swelling and eliminating an external scar and risk of ectropion.

We performed a systematic review to determine the safety and efficacy of the endoscopic management of isolated orbital floor fractures.

METHODS

A systematic review was performed in accordance with the guidelines proposed by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement. Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, EMBASE, MEDLINE “In-Process & Other Non-Indexed Citations,” and MEDLINE electronic databases were searched using a combination of the following medical subject heading terms: orbital fractures, endoscopy, fracture fixation, and maxillary sinus; and keywords: orbital blowout, infraorbital fracture, orbital floor, trapdoor, transantral, transmaxillary, Caldwell-Luc, and transbuccal. Search results were limited to the English language and human subjects.

Two reviewers (K.C. and S.H.V.) independently performed each step of the study selection process. Titles and abstracts from the electronic search results were scanned for potential relevance. Full articles were retrieved for any study that was considered potentially relevant by either reviewer. Studies meeting the following inclusion criteria were selected to undergo data extraction and methodologic quality assessment: studies with primary data of patients with isolated orbital floor fractures who were treated with endoscopic floor reconstruction. Articles were excluded if they included patients younger than 18 years, revision surgery, endoscopic-assisted procedures, or nonisolated orbital floor fractures. Letters to the editor, abstracts, meeting proceedings, and non-English text articles were excluded as well. Studies that reported a mix of patients were included if sufficient data were provided to extract the patients meeting the inclusion criteria. If there was disagreement on the potential relevance of an article, discussion between the reviewers took place until a consensus was achieved, and consultation with an arbitrator (D.D.S.) was undertaken when a deciding opinion was needed. References of selected articles were reviewed for additional studies of relevance.

The 2 reviewers independently assessed the methodologic quality of each study using the Methodological Index for Non-randomized Studies criteria, a 12-point scale validated for both comparative and noncomparative studies. Intraclass correlation coefficient analysis was performed to calculate the level of agreement in quality assessment between the 2 reviewers.

Data were extracted from the selected studies using a standardized template. All relevant study variables were collected, including author, journal, year of publication, study type, sample size, length of follow-up, material used for reconstruction, and complications. Primary outcomes were resolution of diplopia and enophthalmos. Methods for outcomes assessment were recorded as reported by the study authors. Secondary outcomes were postoperative complications, including blindness, paresthesias, sinusitis, infection, conversion to external approach, implant extrusion, and need for revision surgery.

RESULTS

The literature search identified 269 titles and abstracts (Figure). Nine studies met the criterion for inclusion in the systematic review; 2 were comparative studies comparing the endoscopic with the external approach and 7 were case series (Table 1). All studies were retrospective except for 1 case series. A total sample size of 172 patients undergoing reconstruction of the infraorbital floor with an endoscopic approach was captured. Unfortunately, the 9 studies neither were of adequate methodologic quality nor had outcomes homogeneous enough to be combined in a meta-analysis.

Quality assessment of the studies yielded an average score of 6.4 of 16 for the noncomparative studies and 13 of 24 for the comparative studies. High reviewer agreement was observed with an intraclass correlation of 84% (95% CI, 35%-96%). Most studies were significantly limited by the lack of prospective data collection and by biased or nonreproducible outcome assessment. Both comparative studies failed to demonstrate baseline equivalence of the study groups.

Patient and surgical characteristics from the 9 studies are summarized in Table 1. Patient age was reported in 8 studies (mean [range], 30 [18-78] years). Seven studies reported sex; 79 of those 112 patients (71%) were men. Time from injury to surgery ranged from less than 14 days to 47 days; 1 outlier case was performed more than 4 years following the initial injury. Implant materials used for reconstruction varied between studies but included titanium mesh, resorbable poly-L-lactide-polyglycolide copolymer/polyglycolic acid sheet, polyethylene implant (Medpor), maxillary sinus autograft, and no implants. Operative time was reported in 2 studies. Using a Caldwell-Luc type osteotomy, a 30° endoscope, and a 0.4-mm Medpor implant, Fernandes et al reported an initial operative time of 120 minutes for the first few cases, improving to a mean of 70 to 80 minutes. Similarly, using a lateral antrostomy, a 30° endoscope, and a titanium mesh, Nahlieli et al achieved operative times ranging from 60 to 120 minutes. The mean (range) follow-up was 7.6 months (1 week-5 years), and no cases of implant extrusion or cases requiring revision surgery were reported.

A summary of surgical outcomes for noncomparative and comparative studies is presented in Table 2 and Table 3, respectively. Diplopia was assessed at 6 weeks to 3 months after the operation using clinical symp-
Endoscopic approaches to the reconstruction of orbital floor fractures obviate the need for external scars and thus eliminate the risk of ectropion. In patients with a posterior floor fracture or a fracture with a limited posterior shelf, an endoscopic approach may be advantageous for visualization and implant positioning.

COMMENT

Endoscopic approaches to the reconstruction of orbital floor fractures obviate the need for external scars and thus eliminate the risk of ectropion. In patients with a posterior floor fracture or a fracture with a limited posterior shelf, an endoscopic approach may be advantageous for visualization and implant positioning.

Reconstruction of isolated orbital floor fractures can be performed safely and effectively through an endo-

Table 1. Overview of Selected Studies

<table>
<thead>
<tr>
<th>Source</th>
<th>Study Type</th>
<th>No. of Patients</th>
<th>Patient Age, Mean (Range), y</th>
<th>Male Sex, No.</th>
<th>Length of Follow-up, Mean (Range), mo</th>
<th>Time to Surgery, Mean (Range), d</th>
<th>Surgical Approach</th>
<th>Method of Fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheong et al10</td>
<td>Case series</td>
<td>12</td>
<td>25 (18-38)</td>
<td>6</td>
<td>16 (4-49)</td>
<td>21 (2-95)</td>
<td>Transanal</td>
<td>1.5-mm Medpor or 1-mm titanium mesh</td>
</tr>
<tr>
<td>Ducic and Verret1</td>
<td>Case series</td>
<td>63</td>
<td>29 (18-78)</td>
<td>44</td>
<td>NS</td>
<td>NS</td>
<td>Transanal</td>
<td>Autograft from maxillary sinus (n = 39), Medpor alloplasts (n = 14), none (n = 10)</td>
</tr>
<tr>
<td>Fernandes et al</td>
<td>Prospective case series</td>
<td>10</td>
<td>37 (19-47)</td>
<td>7</td>
<td>3 (&lt;1-7)</td>
<td>11 (3-36)</td>
<td>Transanal</td>
<td>0.4-mm Medpor</td>
</tr>
<tr>
<td>Ikeda et al2</td>
<td>Case series</td>
<td>6 of 10B</td>
<td>31 (26-38)</td>
<td>5</td>
<td>7 (6-8)</td>
<td>26 (15-47)</td>
<td>Endonasal</td>
<td>None, balloon for 10-14 d</td>
</tr>
<tr>
<td>Jin et al11</td>
<td>Case series</td>
<td>7 of 11B</td>
<td>35 (22-42)</td>
<td>4</td>
<td>8 (2-34)</td>
<td>10 (5-18)</td>
<td>Endonasal</td>
<td>None, balloon for 4 wk</td>
</tr>
<tr>
<td>Kwon et al12</td>
<td>Retrospective cohort study</td>
<td>43 vs 26</td>
<td>28</td>
<td>NS</td>
<td>7 (&lt;1-42)</td>
<td>NS</td>
<td>Endonasal</td>
<td>None, anterior maxillary wall, or Medpor implant, then balloon for 3-4 wk</td>
</tr>
<tr>
<td>Nahlieli et alb</td>
<td>Case series</td>
<td>9</td>
<td>34 (20-44)</td>
<td>9</td>
<td>7 (2-12)</td>
<td>&lt;14</td>
<td>Lateral</td>
<td>Titanium mesh</td>
</tr>
<tr>
<td>Persons and Wong5</td>
<td>Case series</td>
<td>5</td>
<td>18-41)</td>
<td>4</td>
<td>8 (3-12)</td>
<td>NS</td>
<td>Endonasal vs external transantral</td>
<td>Resorbable PLLA/PGA sheet</td>
</tr>
</tbody>
</table>

Abbreviations: NS, not specified; PLLA/PGA, poly-L-lactic- polyglycolic copolymer/polyglycolic acid.

aAn outlier was excluded (1500 days to surgery).
bFour patients younger than 18 years were excluded.

diagnosis, a field diplopia test, or ophthalmologic consultation. Of the 118 patients with preoperative diplopia, resolution was observed in 102 patients (86%). Enophthalmos was assessed clinically or with a Herthel or Naugle exophthalmometer or ophthalmologic report. Enophthalmos resolved in 41 of the 43 patients (95%) with preoperative enophthalmos.

No study reported complications of blindness, either transient or persistent. Furthermore, there were no complications of sinusitis or dental paresthesias reported. Thirteen patients in 5 of the studies had transient cheek numbness that resolved within 2 months.8,10 No patients undergoing an endoscopic approach required conversion to an external approach. Two patients in whom no implant was used required revision surgery.1 One case of postoperative edema9 and 1 case of orbital cellulitis11 was reported. Three patients with a posterior fracture undergoing an external and/or transorbital approach required revision surgery.12 Another 3 patients undergoing the external approach developed minor complications: 2 developed transient ectropion that improved with massage and 1 developed an intraorbital hematoma.11,12

Table 2. Results of Noncomparative Studies

<table>
<thead>
<tr>
<th>Source</th>
<th>Resolutiona</th>
<th>Assessment</th>
<th>Resolutiona</th>
<th>Assessment</th>
<th>Other Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheong et al10</td>
<td>5 of 7</td>
<td>NS</td>
<td>9 of 10</td>
<td>Naugle exophthalmometer</td>
<td>All had transient (&lt;2 mo) numbness in cranial nerve V2</td>
</tr>
<tr>
<td>Ducic and Verret1</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>2 of 10 with no fixation required revision surgery</td>
</tr>
<tr>
<td>Fernandes et al8</td>
<td>10 of 10</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>1 Had transient (2 mo) numbness in cranial nerve V2</td>
</tr>
<tr>
<td>Ikeda et al2</td>
<td>NS</td>
<td>3-point scale</td>
<td>NS</td>
<td>NS</td>
<td>None</td>
</tr>
<tr>
<td>Jeon et al11</td>
<td>4 of 5</td>
<td>Field diplopia test at 6 wk</td>
<td>7 of 7</td>
<td>Exophthalmometry at 6 wk</td>
<td>NS</td>
</tr>
<tr>
<td>Nahlieli et alb</td>
<td>5 of 5</td>
<td>NS</td>
<td>6 of 6</td>
<td>NS</td>
<td>1 Had postoperative edema</td>
</tr>
<tr>
<td>Persons and Wong5</td>
<td>3 of 3</td>
<td>NS</td>
<td>1 of 1</td>
<td>Ophthalmologic report</td>
<td>NS</td>
</tr>
</tbody>
</table>

Abbreviation: NS, not specified.

aData are given as number of patients.
scopic technique. Both purely endonasal as well as trans-antral endoscopic approaches have been described.\textsuperscript{1,2} Use of these techniques under local anesthesia also has been reported.\textsuperscript{3,11} In this systematic review, rates of resolution of diplopia and enophthalmos were 86\% (102 of 118) and 95\% (41 of 43), respectively. Complication rates were low, with no major complications reported.

These results are comparable with the reported outcomes of traditional external approaches. Yano et al\textsuperscript{10} retrospectively reported their experience managing orbital blowout fractures with an extended subciliary incision during a 5-year period. Enophthalmos resolved in 12 of 14 patients (86\%) and diplopia resolved in 35 of 37 (95\%). Similarly, Gosau et al\textsuperscript{19} retrospectively reviewed 189 of their patients; postoperative enophthalmos was found in 7 (4\%) and persistent diplopia was found in 6 (3\%). Of the 13 patients who had a subciliary approach, 5 patients (38\%) developed an ectropion that required revision surgery. Retrobulbar hematoma occurred in 6 of 189 patients (3\%); 2 of these developed a permanent visual impairment.

To our knowledge, this is the first systematic review of endoscopic techniques for reconstructing isolated orbital floor fractures. The conclusions of this review, however, are limited by the paucity of high-quality studies available for inclusion. Nine studies were identified; only 2 were comparative in design and neither was prospective or randomized. Most of the studies were retrospective with small sample sizes. As a result, rare but significant complications such as blindness, dental injury, or postoperative sinusitis remain a theoretical possibility but were not observed.

The likelihood of outcome reporting bias may further limit these results.\textsuperscript{7} Although diplopia resolved in 102 of 118 patients, the presence or absence of preoperative diplopia as an outcome was not reported for 54 patients (31\% of the total number of patients across all studies). Resolution of enophthalmos is at an even greater risk for outcome reporting bias because the presence or absence of enophthalmos was not reported for 129 patients (75\% of patients). Properly designed prospective comparative studies with defined inclusion criteria are required. Clinically relevant outcomes should be defined a priori and assessed in a validated and reproducible manner.

The choice of implant material used for reconstruction remains variable. Several authors used titanium mesh,\textsuperscript{9} whereas others used Medpor sheets.\textsuperscript{3} Some used autografts from the anterior maxillary sinus wall.\textsuperscript{1} Cheong et al\textsuperscript{19} used 1.5-mm Medpor sheets if the defect did not involve the infraorbital nerve or posterior shelf; otherwise, a 1-mm titanium mesh was used. Our team has used nasal septal cartilage because this is readily available through the endonasal approach. Others do not use any material for reconstruction.\textsuperscript{2,11,13} Evidence supporting the use and type of implant material is insufficient, and thus we are unable to draw any conclusions regarding this issue.

Different techniques for supporting the reconstructed floor postoperatively have also been described.\textsuperscript{11,13} Some authors advocate for the use of a Foley catheter, whereas others describe a custom-made balloon catheter using the finger of a glove or small pediatric feeding tube.\textsuperscript{11,13} Despite these variations in technique, endoscopic reconstruction of orbital floor fractures appears to be safe and effective.

In this systematic review, endoscopic reconstruction of the orbital fractures was limited to isolated orbital floor fractures. Endoscopic reconstruction of the medial orbital wall also has been described.\textsuperscript{16,17} In patients with concomitant orbital rim fractures, traditional reconstruction with a transorbital approach may be preferred. Furthermore, although pneumatized maxillary sinuses are required for an endoscopic approach, successful reconstruction with an endoscopic approach has been described in patients as young as 5 years.\textsuperscript{18} It is generally accepted that most children will have substantial pneumatization of the maxillary sinus by the age of 3. Other considerations include nostril size and the ability to work in a more confined space. Pediatric-sized instrumentation and endoscopes are available.

As the trend toward minimally invasive surgery continues, endoscopic techniques are finding an increasing role in many disciplines. During the past decade, there has been a substantial expansion of the role of the endonasal technique to manage pathologic characteristics of the skull base and orbits. Reports of orbital and optic nerve decompression are abundant in the literature as well as those of intraorbital access for the treatment of tumors and abscesses.\textsuperscript{19,20} Endoscopic dacryocystorhinostomy has been a well-established technique for more than a decade.\textsuperscript{21,22} Owing to the avoidance of external scars and improved visualization, especially for posterior orbital floor fractures, it is natural to extend this tool to the application of orbital floor fracture management.

### Table 3. Results of Comparative Studies

<table>
<thead>
<tr>
<th>Source</th>
<th>Diplopia</th>
<th>Enophthalmos</th>
<th>Resolution a</th>
<th>Other Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jin et al\textsuperscript{11}</td>
<td>3 mo Herthel exophthalmometer</td>
<td>8 of 15</td>
<td>4 of 4</td>
<td>Orbital cellulitis (n = 1)</td>
</tr>
<tr>
<td>Kwon et al\textsuperscript{12}</td>
<td>Symptoms at 8 wk NS</td>
<td>38 of 43</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Resolution b</td>
<td>Diplopia</td>
<td>Enophthalmos</td>
<td>Resolution b</td>
<td>Other Complications</td>
</tr>
<tr>
<td>Jin et al\textsuperscript{11}</td>
<td>3 mo Herthel exophthalmometer</td>
<td>9 of 22</td>
<td>7 of 10</td>
<td>Ectropion improved with massage (n = 2), intraorbital hematoma (n = 1)</td>
</tr>
<tr>
<td>Kwon et al\textsuperscript{12}</td>
<td>Symptoms at 8 wk NS</td>
<td>20 of 26</td>
<td>NS</td>
<td>Revision surgery in patients with posterior fractures (n = 3)</td>
</tr>
</tbody>
</table>

Abbreviation: NS, not specified.

\textsuperscript{a}Data are given as number of patients.
As with all new techniques, endoscopic reconstruction of isolated orbital floor fractures must be evaluated and compared with “tried and true” techniques. Although initial reports are heterogeneous, both in technique and reporting of outcomes, they do provide a reasonable base from which to start this evaluation. Endoscopic repair of isolated orbital floor fractures, through either a purely endonasal or a transantral route, appears to be a promising technique with acceptable safety and efficacy. Further studies will need to be assessed as techniques evolve and more centers report their outcomes.

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REFERENCES