Applications of the Endoscope in Facial Fracture Management

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ABSTRACT

The aesthetic necessity to preserve an undisturbed facial appearance and function has led to the progressive adoption of less-conspicuous incisions and decreasingly aggressive exposure in the treatment of facial injuries. The goals of proper anatomic reduction and stable fixation, however, must not be omitted. The introduction of endoscopic techniques has allowed a harmonious union of these two seemingly competing objectives. In condylar injuries, the endoscope may be used to restore preinjury condylar height and angulation, avoiding the feared risks of facial nerve injury and visible scarring. Treatment of complex zygoma and LeFort III fracture cases may be facilitated by repairing the zygomatic arch through remote stab incisions, obviating the need for an extensive coronal exposure. Endoscopically assisted treatment and diagnosis of orbital floor fractures decreases the risks of lower eyelid malpositioning without predisposing to the development of enophthalmos or hypophthalmos. Similarly, depressed frontal sinus injuries may be reduced or camouflaged via hidden incisions, significantly reducing stigmata of surgical entry. In the overview to follow, the application of endoscope-assisted techniques to the treatment of the above fractures will be presented. The rationale for use, specific operative indications, bailout strategies, and outcome studies will be discussed.

KEYWORDS: Endoscope, facial fractures

The current management of facial trauma has evolved from the fundamentals of orthopedic surgery of the long bones. The main principles are still shared: visualized anatomic reduction and rigid fixation. The aesthetic concern for preservation of an undisturbed facial appearance and function, however, has led to the progressive adoption of less-conspicuous incisions and decreasingly aggressive exposure.

Healed small, well-hidden incisions will not break up facial surface contour or aesthetic balance. Thus, stigmata of a surgical procedure are avoided. Moreover, scarring not only affects surface topography but may also damage the function of delicate structures, such as the eyelid, and result in a disabling ectropion.

Exposure using long, directly overlying incisions increases the risk of damage to any intermediate structures. In the face, the complex and difficult to predict course of the facial nerve make it especially prone to injury, with disastrous consequences. Inadvertent disruption of numerous sensory nerves or hair follicles when using the traditional coronal or gull-wing approaches may lead to dysesthesias and scar alopecia, respectively. Furthermore, large incisions in the head and neck region may lead to significant blood loss and even transfusion requirements.¹

Aggressive, unrepaired skeletal degloving may irreversibly alter facial support and vascularity leading to premature soft-tissue descent and bony fragment

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Frontiers in Endoscopic Plastic Surgery; Guest Editor, Geoffrey G.

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Semin Plast Surg 2008;22:29–36. Copyright © 2008 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

DOI 10.1055/s-2007-1019140. ISSN 1535-2188.

resorption.² The resultant asymmetry is often as undesirable as the initial injury.

Because of the undesirable sequelae of wide-open surgical access, some facial fractures continued to be treated conservatively using nonrigid techniques with increased risk of residual skeletal malreduction. In functionally demanding structures, such as the mandible, the prolonged immobilization necessitated a lengthy rehabilitative regimen and caused significant weight loss.

The introduction of the endoscope to facial trauma care has allowed the surgeon to achieve the laudable goal of stable anatomic reduction while taking maximal advantage of minimal access approaches. First, long lever arms and magnification capabilities of endoscopic instruments permit working through small stab incisions located away from important structures. Second, strategic exposure using precise equipment decreases the need for wide soft-tissue degloving.

The delayed integration of the endoscope to the plastic surgeon's armamentarium was partly the result of an absence of naturally occurring, sufficiently large optical cavities in the head and neck region. As well, the requirements for specialized instrumentation, a different set of surgical skills, and initially lengthy operative times detracted from initial widespread use of endoscopic techniques.

Today, endoscope-assisted techniques of facial trauma repair are becoming increasingly popular. Philosophically, the endoscope serves two principal roles in facial trauma management. It decreases morbidity of surgical access in the treatment of fractures where open reduction and internal fixation (ORIF) was considered standard. It also allows for anatomic reduction and stabilization of fractures such as the mandibular condyle, which was previously addressed conservatively because of perceivably unacceptable operative risks.

In the overview to follow, the application of endoscope-assisted techniques to the treatment of condylar, zygomatic arch, and orbital and frontal sinus fractures is presented. The rationale for use, specific operative indications, bailout strategies, and outcome studies are discussed.

APPLICATIONS

Mandibular Condyle

RATIONALE

Condylar injuries are relatively frequent, accounting for 20 to 50% of all mandibular fractures.³ Traditional treatment consists of a variable period of rigid maxillo-mandibular fixation (MMF). Recent outcome studies, however, have shown the failure of this technique to restore normal anatomy. The malunion of the condyle leads to aesthetic and functional disturbances.⁴⁻¹²

Because of fragment override, the malunited condyle is most often shortened. As the resting tone of masticatory, suprahyoid, and infrahyoid musculature seeks to reposition the condylar head back into the glenoid fossa, the mandibular plane undergoes a clockwise rotation, leading to an unappealing loss of chin projection at the pogonion and an anterior open bite deformity. Premorbid occlusion is restored only rarely, at times of forced maximal intercuspation, through neuromuscular adaptation at the temporomandibular articulation. Furthermore, dynamically there is ipsilateral jaw deviation due to unequal ramal length. The unopposed lateral pterygoid muscle pull leads the condyle to heal in an anteroposteriorly flexed posture, resulting in its premature contact with the anterior wall of the glenoid fossa. This limits inter-incisal opening to only the initial hinge motion of 20 to 25 mm. Normal temporomandibular joint biomechanics are precise and complex. A malunited condyle readily disturbs these relationships through changes in movement and loading patterns. In the long-term, these alterations have a marked potential for causing internal derangement. In addition, because of bilateral interdependence of the condyles, the contralateral temporomandibular joint is also at risk of premature degenerative changes.

MMF also has other disadvantages including discomfort, weight loss, and the need for a lengthy regimen of muscular and occlusal rehabilitation to recover muscle function and condylar range of motion.^{13,14}

In spite of advantages to the use of ORIF, there has been reluctance toward its application to condylar fractures, caused by the risks of facial nerve injury, visible cutaneous scarring, and technical challenge.¹⁵ The risk of permanent facial palsy averages 1% and is considered by most to be worse than the consequences of non-anatomic treatment.¹⁶

The endoscope allows the restoration of normal condylar anatomy minimizing the risks of open treatment. Exposure and fixation of the fracture intraorally avoids crossing the course of the facial nerve. The small stab incision needed for screw insertion rarely results in a perceptible scar (Fig. 1). Thus, the negative sequelae of condylar malunion, a frequent outcome of MMF, should no longer be an accepted outcome.

INDICATIONS

The objectives of condylar fracture treatment include pain-free mouth opening with inter-incisal distance more than 40 mm, good movement of the jaw in all excursions, preinjury occlusion of the teeth, stable temporomandibular joints, and good facial and jaw symmetry.¹⁷

Anatomic realignment of the condyle is required to achieve these goals in all displaced, extracapsular adult fractures. Nondisplaced, nondislocated injuries

Figure 1 Endoscopic technique of condylar fracture repair. (A) After an incision over the oblique line of the mandible, a subperiosteal dissection exposes the fracture site and establishes the optical cavity. (B) A second portal is made directly over the fracture site. It is used for the insertion of a trocar, allowing for proximal condylar pole realignment and percutaneous screw fixation. (C) An optional third portal may be placed at mandibular angle, allowing for further fracture fragment manipulation. (From Lee C, Forrest C. Endoscopic Facial Fracture Management: Techniques. *Mathes Plastic Surgery* 2006;68:463–509. Reprinted by permission.)

frequently have sufficient periosteal support to allow healing in normal position using MMF. Intracapsular fractures generally do not demonstrate significant loss of ramal height, and closed treatment can be expected to produce few unfavorable functional and aesthetic sequelae. Fractures in prepubertal patients demonstrate an immense potential for condylar rehabilitation through growth and remodeling.^{18,19}

Thus, the use of endoscope-assisted ORIF (EAORIF) should be considered in all injuries where anatomic realignment is considered necessary to achieve normal function and appearance. Furthermore, use of this approach requires preoperative confirmation of feasibility. High condylar neck fractures that do not allow placement of at least 2 screws on the proximal segment, severely comminuted fractures not permitting interfragmentary compression, and dislocated injuries are considered contraindications.¹⁶

OUTCOMES

When used selectively, EAORIF can be expected to produce accurate anatomic reduction and stable fixation in 94% of cases.¹⁶ If the surgeon is unable to complete endoscopic repair, he or she should resort to

the method of condylar repair that would customarily be used.

The largest published series of endoscopically treated condylar fractures comprises 135 patients. Complications cited include malreduction (4%), plate fracture (2%), interincisal opening < 35 mm (< 4%), and temporary facial nerve palsy (< 2%). There have been no reported incidences of permanent facial nerve injury.¹⁶

Zygomatic Arch

RATIONALE

The zygomatic arch can be injured in isolation or as a component of zygoma or LeFort III level fractures. Its consistent shape and strategic connection to the stable skull base make the arch an important component in the repair of these midfacial injuries.^{20,21} In complex zygoma fractures, frequent comminution at the anterior buttresses precludes their proper anatomic realignment, and the arch serves as a guide to re-creation of premorbid facial projection and width. In LeFort III fractures, the arch forms a key fixation pillar, stabilizing the dentition to the base of skull. Repair of isolated arch injuries is also

important in individuals with prominent preinjury arch contour, as malreduction or unstable repair may lead to an aesthetically displeasing lateral facial flattening.

Repair of the arch using the traditional coronal approach is not without drawbacks. Traction or transection injuries of the frontal branch of the facial nerve, scar alopecia, scalp dysesthesia, and significant blood loss are but some of the detractors of the technique.¹ The nonvisualized reduction method of Gillies has been advocated.²²⁻²⁴ It is important to realize, however, that this technique is only useful when the arch is angulated medially, noncomminuted, and no fixation is required. It may, at best, be adequate for "in-buckled" simple arch fractures or minimally displaced zygoma injuries with incomplete frontozygomatic suture disruption.

Endoscopic repair of the arch requires small, innocuous scalp incisions. Dissection underneath the superficial layer of the deep temporal fascia prevents injury to the facial nerve. Direct, magnified visualization of the arch confirms proper reduction (Fig. 2). The benefits of open repair may thus be achieved without the drawbacks of extensive incisions.

INDICATIONS

Goals of zygomatic arch repair include restoration of its preinjury shape and stability. When these objectives must be fulfilled to restore stable, accurately reduced midfacial structure, then EAORIF of the arch should be considered. Most commonly, endoscopic assistance is required in complex zygoma fractures, LeFort III level injuries, and in isolated arch fractures of patients with prominent contralateral arch contours. EAORIF is unnecessary whenever a coronal flap must be raised for the treatment of other fractures, such as naso-orbito-ethmoidal, posterior table of the frontal sinus, or displaced skull fractures.

In complex zygoma injuries, arch repair is generally undertaken after frontozygomatic and infraorbital buttress reduction. The zygomaticomaxillary interface is addressed last. In LeFort III injuries, the cranio-orbital unit is repaired similarly to a zygoma. After reestablishment of preinjury occlusion using MMF, the midface is joined to the dentition at the LeFort I level.

OUTCOMES

If endoscopic repair cannot be performed, traditional coronal exposure is recommended. Combined results from the four largest published endoscopic arch repair series, comprising 78 patients, show very low complication rates.²⁵⁻²⁸ The reported incidence of temporary facial nerve palsy is 5.6% (3/53). Chen describes no incidence of nerve palsy using dissection under the superficial layer of deep temporal fascia (0/25). He credits this to a greater level of protection against mechanical retraction afforded by a thicker layer of tissue. There have been no reported cases of permanent

Figure 2 Endoscopic technique of zygomatic arch repair. (A) An incision in the temporal hairline is made, and dissection is performed superficial to the deep temporal fascia. The endoscope is inserted to minimize the risk of injury to the facial nerve and exposes the zygomatic arch in a subperiosteal plane. (B) After in situ reduction, a miniplate is used to span fracture fragments and secure the midface to the skull base posteriorly. (From Lee CH, Lee C, Trabulsy PP, et al. A cadaveric and clinical evaluation of endoscopic assisted zygomatic fracture repair. *Plast Reconstr Surg* 1998;101:333-345. Reprinted by permission.)

palsy. There is no risk of temporal hollowing when the deep temporal fascia is not completely violated. No cases of late enophthalmos have been reported. Ex vivo arch plating is associated with a 25% resorption rate (3/12).

Figure 3 Endoscopic orbital floor repair. (A) The anterior wall of the maxillary sinus is exposed through an upper-buccal sulcus incision, and a Caldwell-Luc antrostomy is performed. (B, C) The endoscope is inserted into the sinus cavity, and important landmarks including maxillary sinus ostium and infraorbital nerve are visualized. Orbital floor defect and fracture pattern is defined. (From Lee C, Forrest C. Endoscopic Facial Fracture Management: Techniques. *Mathes Plastic Surgery* 2006;68:463–509. Reprinted by permission.)

Orbital Floor

RATIONALE

The orbital floor provides an important support for the ocular globe. Its fracture may significantly increase the orbital volume and result in inferior or posterior globe displacement. Hypophthalmos and enophthalmos are not only aesthetically displeasing but also may interfere with binocular vision. Moreover, a break in the floor may entrap periorbital tissues causing a mechanical restriction to extraocular movements. If the entrapment interferes with blood supply to the extraocular muscles, the resultant ischemia may cause permanent injury, a phenomenon more frequently seen in children.²⁹

Conventionally, the orbital floor was exposed transcutaneously, either at the subciliary, subtarsal, or the infraorbital level of the lower eyelid. Disrupting the anterior lamella of the eyelid may lead to visible scarring, scleral show, ectropion, and malar fat pad descent.^{30,31} The relatively newer transconjunctival incision presents significantly less morbidity but is not devoid of complications. Ectropion, entropion, and inferior oblique

muscle injury have all been described.³² Furthermore, access through the lower eyelid may present difficulties in identifying the posterior edge of the fractured floor, resulting in unstable implant placement.

The endoscope allows the surgeon to approach the orbital floor through a remote, intraoral incision. Repair via the maxillary antrum potentially decreases the amount of intraorbital manipulation and facilitates identification of a stable posterior shelf (Fig. 3). In addition, the endoscope may be used to diagnose clinically significant fractures when computed tomography (CT) data are unavailable or inadequate.³³

INDICATIONS

Endoscopic assistance should be considered in all fractures where surgical exploration is required, namely floor fractures greater than 2 cm² or 50% of total floor area and mechanical entrapment restricting periorbital tissues. Injuries most easily repairable with the endoscope include trapdoor and medial orbital blowout fractures.³⁴ Trapdoor fractures are frequently stable after reduction and can be left without fixation. Medial blowout injuries can

be treated using a small Medpor implant (Porex Surgical, Newnan, GA) or mesh. Fractures lateral to the infraorbital nerve or those involving the medial orbital wall require more extensive dissection and implant fixation. These are probably best exposed through the lower eyelid.

Using the "pulse test," the endoscope provides valuable diagnostic information when proper coronal CT images are unavailable or when imaging information is no longer accurate; for example, after the reduction of a zygoma fracture.³³

OUTCOMES

Nine series of endoscopically treated orbital floor injuries, comprising 204 cases, have been published.³⁴⁻⁴¹ No instances of orbital hemorrhage or optic nerve, ocular globe, or extraocular muscle injury have been reported. Diplopia was improved in all patients; 19% had some residual double-vision. Caldwell-Luc antrostomy does not result in contour deformities. Using the endonasal technique, excessive enlargement of the ostium anteriorly may injure the nasolacrimal duct.

Frontal Sinus

RATIONALE

A displaced fracture of the anterior table of the frontal sinus will cause an unsightly depression in forehead contour. The severity of the displacement depends on individual sinus geometry, thickness, and energy of the injury. If the fracture line traverses the frontonasal duct, it may obstruct it, predisposing to the formation of a mucocele or mucopyocele.

Anatomic reduction of displaced segments and defunctionalization of an obstructed sinus may be performed through a myriad of incisions: direct transverse forehead, vertical corrugator crease, bilateral brow-glabella, and coronal. All are associated with significant drawbacks including unsightly scars, brow and scalp alopecia, forehead and scalp dysesthesias, and nontrivial blood loss.¹ In certain patients, especially those with short or receding hair, the sequelae of access may be more undesirable than some unrepaired injuries.

The endoscope allows approach to the sinus through small incisions hidden behind the hair line. As well, it permits magnified visualization of the frontonasal duct allowing a more careful inspection of its patency³³ (Fig. 4).

INDICATIONS

Endoscopic frontal sinus repair is indicated whenever repair of the anterior table fracture is judged important to restore the contour of the forehead but neither sinus obliteration nor cranialization are necessary. The endoscope should be used to repair significantly displaced anterior table fractures only. Displaced posterior table

Figure 4 Endoscopic technique of frontal sinus fracture repair. (A) The endoscope is inserted through a portal behind the frontal hairline. To increase the size of the optical cavity, a traction suture is placed directly over the fracture region. (B) Miniplates and screws are inserted through stab incisions in frontal expression lines, and fracture segments are percutaneously secured. (From Lee C, Forrest C. Endoscopic Facial Fracture Management: Techniques. *Mathes Plastic Surgery* 2006;68:463-509. Reprinted by permission.)

fractures or blockage of the frontonasal duct are contraindications. In anterior table fractures, the endoscope may also help determine patency of the frontonasal drainage system. Contraindications to the technique include severe comminution, associated orbital roof blow-in fractures, and fractures that extend over the orbital rim. Concomitant fractures necessitating a coronal approach obviate the need for the endoscope.

The endoscope may also serve as an adjunct to the coronal approach in patients with extensive supraorbital sinus recesses requiring removal of sinus mucosa. Here, it may help reach small sinus extensions without a frontal osteotomy.³³

OUTCOMES

Stab incisions in the glabellar region tend to heal without any sequelae. The difficulties with EAORIF include

manipulation and percutaneous fixation of small bone fragments, which may significantly prolong operative times. If comminution is excessive, a coronal approach or a camouflage technique, using an overlay mesh, may be used.⁴² One published series of endoscopically treated patients found the outcome to be satisfactory in all cases, no complications, and no requirements to convert to a more extensive incision.⁴³

CONCLUSION

The endoscope is revolutionizing the field of facial trauma management. It allows for visualized anatomic reduction and rigid fixation without the large cutaneous incisions used in the past. The risks of visible scarring, injury to neurovascular structures, and excessive blood loss are thus minimized. The endoscope's magnification may potentially permit more accurate repair and exposure in deep, dangerously located cavities. In the long-term, endoscopic assistance has the potential of shortening operative times. Clearly, the endoscope has proved its place in plastic surgery. We must now work to further improve current techniques, clarify treatment indications, and objectively assess our outcomes.

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