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The Rationale and Technique of Endoscopic Approach to the Zygomatic Arch in Facial Trauma

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Endoscopy was introduced to the field of facial plastic surgery relatively late by Vasconez and colleagues [1], who were the first to perform an endoscopic brow lift in 1994. This initial delay in the assimilation of the endoscope in the head and neck region likely was caused by the absence of naturally occurring body cavities, such as the abdomen or a joint space, which greatly facilitate its application in general and orthopedic surgeries. In addition, initial endoscopic instruments lacked specificity to the facial region.

Despite this late introduction, the use of endoscopy rapidly progressed as the advantages of minimal access were realized. Sakai and colleagues [2] extended endoscopic applications to the management of craniofacial disorders, performing a Le Fort I level osteotomy. Lee and colleagues [3,4] and Kobayashi and colleagues [5] pioneered the use of endoscopy in the area of the zygomatic arch. Since their original descriptions, several modifications to their techniques have been proposed. These vary in placement of incisions, planes of dissection and methods of fixation [6,7]. The endoscope currently is considered by many to have an integral role for managing injuries in this region.

This article presents the authors' experience with the endoscopic technique of zygomatic arch repair, the evolution and advantages of its present indications, and future directions.

The role of arch anatomy and use of endoscopy to minimize treatment pitfalls

The zygomatic arch is a narrow skeletal element spanning from the temporal bone to the zygoma body. In the axial plane, the arch is curved in the

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Fig. 1. Medial arch displacement occurs following direct lateral force. (*From* Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20(3):231–8, with permission.)

posterior third of its course and straight in the anterior two thirds. In the sagittal plane, it is parallel to the Frankfort horizontal. The arch also occupies a strategic position, joining the midface, which frequently is displaced in facial trauma, to the stable skull base. Numerous authors have taken advantage of these properties, using the arch's bony attachments and consistent shape as a guide to anatomically repairing it and the midface without the necessity of exposing the contralateral, uninjured part of the skull as a control [8,9].

The role of the arch in midfacial repair can be viewed threefold. First, it can be used as a guide to precise fracture realignment, to accurately restore midfacial projection and transverse width. Second, it can serve as an anchor point of the midface because of its sturdy skull base attachment. Last, its anatomic reduction is paramount to aesthetic appearance in individuals with prominent preinjury lateral facial contour.

Despite its key role, the advantages of arch repair have not been used sufficiently, as access to it is fraught with difficulties. Incisions cannot be placed directly over the arch because of high risk of facial nerve injury. The facial nerve pierces the superficial musculoaponeurotic system at its lower border and courses superficially to the temporoparietal fascia in an anterosuperior direction [10]. Instead, the coronal approach designed to avoid injury to the facial nerve traditionally has been used. The latter has its own drawbacks, however, including alopecia, anesthesia posterior to the incision, risks of traction injury to the frontal branch of the facial nerve and temporal hollowing, and excessive blood loss [4]. Consequently, the principle of anatomic reduction and rigid internal fixation, standard in other facial trauma repair, has been applied infrequently to the zygomatic arch.

The use of endoscopy allows the surgeon to fully benefit from the role of arch repair while minimizing the negative sequelae of traditional access. This technique also offers other advantages, including magnified direct visualization, and in the long-term, a potential for increased quickness [11] and cost-effectiveness.

Arch injury patterns

Fractures of the zygomatic arch can occur in isolation or with midfacial injuries. The individual pattern depends mainly on the magnitude and direction of the trauma force vector applied to the craniofacial skeleton.

Isolated arch fractures can be of three types. First, direct lateral force displaces the arch medially [Fig. 1]. Second, an anterior force vector focused on the malar prominence usually will cause a posterior telescoping pattern of injury [Fig. 2]. At times, however, a posteriorly directed force can result in an explosive burst with displacement of the arch fragments laterally [Fig. 3]. Recognition of the latter two injury patterns is important, as a nonvisualized reduction attempt, using an elevator inserted under the arch, will be unsuccessful and exacerbate fracture displacement.

A displaced zygoma fracture results from disruption of all its bony attachments, of which the zygomatic arch is a necessary component. Most frequently, it arises because of a force applied directly to the malar prominence with dissipation

Fig. 2. Posterior telescoping fracture of the arch results when energy applied anteriorly to the malar prominence is transmitted to the arch segment. (*From* Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20(3):231–8, with permission.)

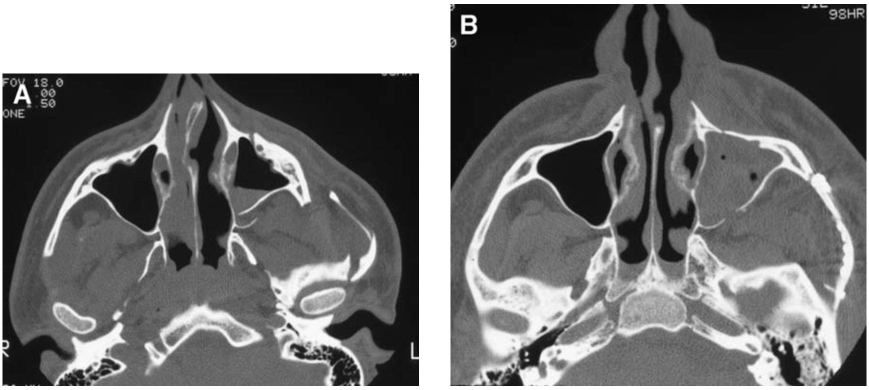

Fig. 3. (*A*) Zygomatic arch fragmentation with lateral displacement of the segments occurs when a high energy force is applied anteriorly at the zygoma and dissipates posteriorly at the arch. (*B*) Successful anatomic repositioning of the lateralized arch fragments. (*From* Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20(3):231–8, with permission.)

of much of the energy at the anterior, zygomaticomaxillary, and infraorbital buttresses. Only higher energy mechanisms will have a sufficient portion of the force transmitted posteriorly to cause arch disruption. The magnitude of energy determines the degrees of displacement and comminution [12]. A displaced zygoma fracture results in malar prominence depression and may cause enophthalmos because of orbital enlargement.

A Le Fort III-level fracture is defined in part by separation of the maxilla from the cranial base at the zygomatic arch. It occurs in high-energy injuries in which the force vector fractures across the alveolus and the pterygoid plates, resulting in a mobile maxilla and its attached dentition. Disruption of the stable arch attachment causes occlusal instability in addition to midfacial flattening, widening, and asymmetry.

Endoscopic indications and rationale for repairs

In the authors' experience, endoscopic approach to the arch should be considered in all cases where precise arch repair is deemed an integral part of the treatment plan. Thus, when the zygomatic arch is thought to contribute to proper reduction or enhanced stability of other facial fractures, or when the arch itself is considered an important aesthetic landmark, the surgeon should attempt endoscopic reduction and fixation. This approach allows effective fracture management while minimizing the stigmata of extensive incisions.

In Le Fort III-level injuries, the principal benefit of rigid arch fixation is to stabilize the mobile maxilla and its attached dentition to the skull base. This ensures a secure maxillomandibular occlusal relationship. The arch is a particularly valuable point, as the other anterior buttresses frequently are comminuted. The secondary role of the arch in Le Fort III fractures is to enhance accurate midface realignment.

In displaced zygoma fractures, arch reduction is a valuable tool for anatomic repositioning of the malar prominence to recreate preinjury facial width and projection. It may, in addition, restore adequate orbital volume. This is paramount in complex zygoma fractures when there is extensive comminution of at least two of the anterior three zygoma buttresses. In these injuries, the arch also serves as an additional point of rigid fixation.

In isolated arch fractures, repair is particularly important in individuals with prominent preinjury lateral facial contour. Failure of realignment will lead to an unsightly temporal depression and asymmetry. In addition, miniplate placement will prevent subsequent arch redisplacement caused by reinjury or pull by the masseter muscle, an issue not addressed by the Gillie's approach.

Repair sequencing

In the authors' experience, when the complexity of facial trauma necessitates incorporation of arch repair into a comprehensive management plan, the following sequences are most effective.

Le Fort III

The authors approach the repair of these fractures by individually treating the cranio–orbital and maxillomandibular units, subsequently uniting them at the Le Fort I level. The cranio–orbital unit is addressed by first reducing and fixating the external orbital frame at the infraorbital and zygomaticofrontal interfaces. The arch then is repaired to provide appropriate projection and width to the midface. Premorbid occlusion is restored using maxillomandibular fixation. Next, the two functional units are joined using miniplates at the zygomaticomaxillary and nasomaxillary buttresses.

Complex zygoma

Complex zygoma fracture may require repair of all the anterior buttresses, including: zygomaticofrontal, infraorbital and zygomaticomaxillary, along with the zygomatic arch. Repair is accomplished most expediently by first restoring the external orbital frame, then reducing and fixating the zygomatic arch. The zygomaticomaxillary buttress is addressed last.

Surgical technique

Equipment

The equipment used at the authors' center includes: a 4 mm diameter 30° angle scope (Karl Storz, Germany), a 4 mm endoscope mounted retractor (Isse Dissector Retractor, Karl Storz, Germany), which maintains the optical cavity, and a video system (Olympus America, Lake Success, New York) to project the endoscopic image onto a monitor display.

Exposure

A scalp extension of the preauricular incision is carried through the skin and the temporoparietal fascia to expose the deep temporal fascia. A periosteal elevator then is inserted, and an optical cavity is created by dissecting superficial to the deep temporal fascia. This nonvisualized part of the dissection is performed only superior to an imaginary line extending from the helical crus to the superior orbital rim. This minimizes the risk of injury to the frontal branch of the facial nerve. Following dissection of the optical cavity, a retractor-mounted endoscope is inserted, and directly visualized dissection in the same plane is performed down to the zygomatic arch. Maintenance of integrity of the deep temporal fascia helps to avoid unsightly temporal hollowing. Once the arch is reached, its periosteum is incised, and the sites of fracture are exposed in the subperiosteal plane [Fig. 4].

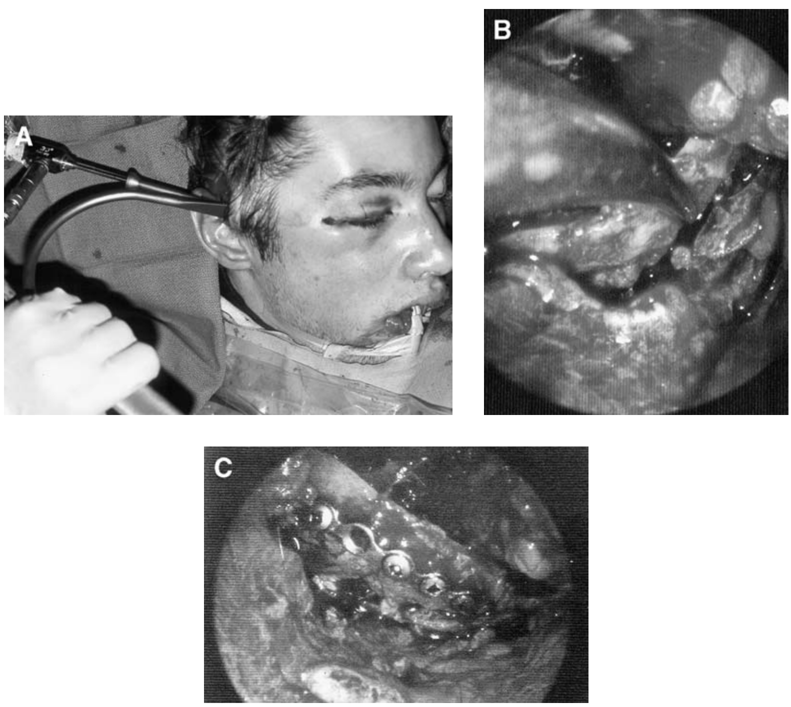

Fig. 4. (*A*) Endoscopic repair of the arch is performed using a small incision hidden in the temporal hairline. The retractor-mounted endoscope is inserted, and directly visualized dissection is performed in a plane superficial to the deep temporal fascia down to the zygomatic arch. (*B*) Endoscopic view demonstrates medially displaced arch segments. (*C*) Following repair, arch fragments are seen in their anatomic position. (*From* Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20(3):231–8, with permission.)

Reduction

Following exposure, arch fragments are reduced according to the fragmentation pattern to restore preinjury arch form. This is preferably done in situ. If excessive comminution prevents stability and does not allow in situ reduction, the fragments can be removed and precisely realigned on a side table. This, however, carries a significant risk of bony resorption, as the periosteal blood supply is interrupted [13].

Fixation

Selection of appropriate fixation hardware depends on the type of fracture. A short miniplate is used in isolated arch injuries, whereas a long mini-adaptation plate is preferred in associated midfacial trauma. The long mini-adaptation plate extends onto the lateral orbital rim, restoring and rigidly stabilizing the midface. Following fixation of the plate to an arch segment, either in situ or on a side table, accurate reduction is confirmed, and the plate is stabilized to other fracture segments using the endoscope [see Fig. 4].

Case presentations

Le Fort III

A young male was assaulted with a baseball bat. On examination, the left side of his face was visibly flattened; the entire maxillary segment was mobile, and he complained of malocclusion. CT imaging revealed left Le Fort III and right Le Fort II facial fractures. In the operating room, premorbid occlusion initially was restored using maxillomandibular fixation. Access for repairs was achieved using preauricular (endoscopic arch fixation), lateral extension of upper blepharoplasty (zygomaticofrontal buttress), and upper buccal sulcus incisions (inferior orbital rim and zygomaticomaxillary buttress). The arch component of the Le Fort III fracture was plated rigidly as a free graft ex vivo and then repositioned accurately to help stabilize and reduce the midfacial injury [Figs. 5, 6].

Complex zygoma

A male involved in a motor vehicle collision was brought to the hospital. During the trauma, the left side of his face struck the steering wheel. He complained of left cheek flatness and pain, and anesthesia in the left infraorbital nerve distribution. In addition, he sustained a left lateral orbital laceration. CT imaging demonstrated a left zygoma fracture with lateral displacement of the comminuted arch. Access for fracture repair was by means of preauricular (endoscopic arch fixation), lateral orbital laceration (zygomaticofrontal buttress), and upper buccal sulcus incisions (inferior orbital rim and zygomaticomaxillary buttress). The significantly comminuted arch component was plated ex vivo and then repositioned anatomically as the arch element of four-point zygoma fracture reduction and fixation [Figs. 3, 7].

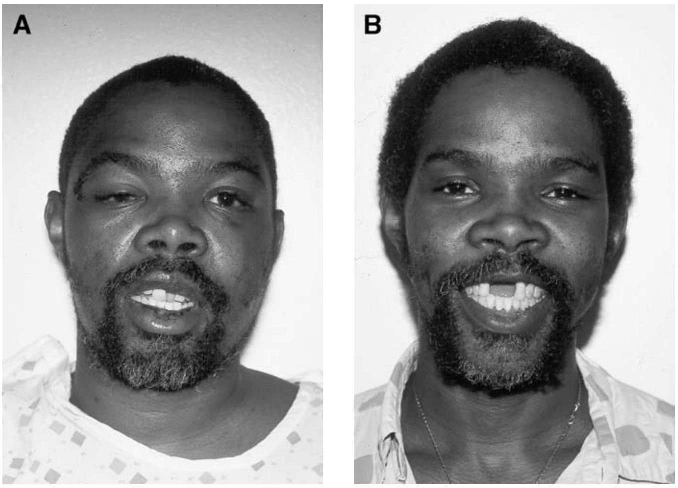

Fig. 5. (*A*) Preoperative photograph of a patient who sustained a left Le Fort III and right Le Fort II facial fractures. Midfacial flattening and malocclusion are evident. (*B*) Photograph several months following endoscope-assisted repair. (*From* Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20(3):231–8, with permission.)

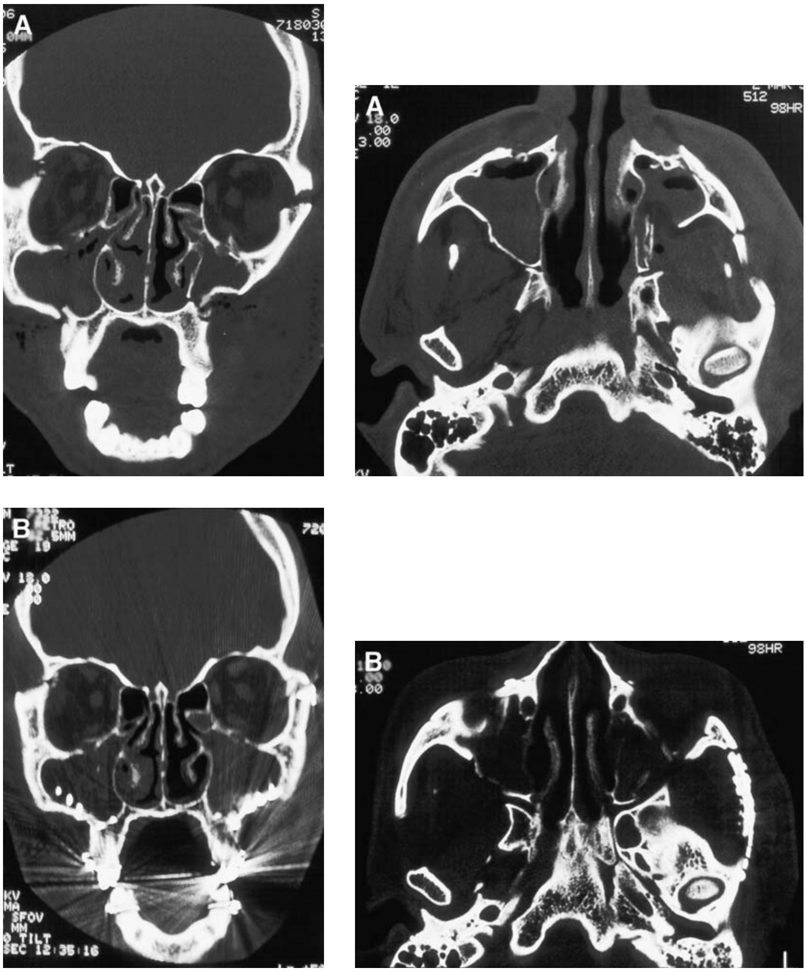

Fig. 6. (*A*) Coronal and axial CT images demonstrating left Le Fort III and right Le Fort II level injuries with severe left zygomatic arch comminution. (*B*) Following endoscope-assisted repair, anatomic realignment of midfacial anatomy and restoration of preinjury occlusion can be seen. (*From* Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20(3):231–8, with permission.)

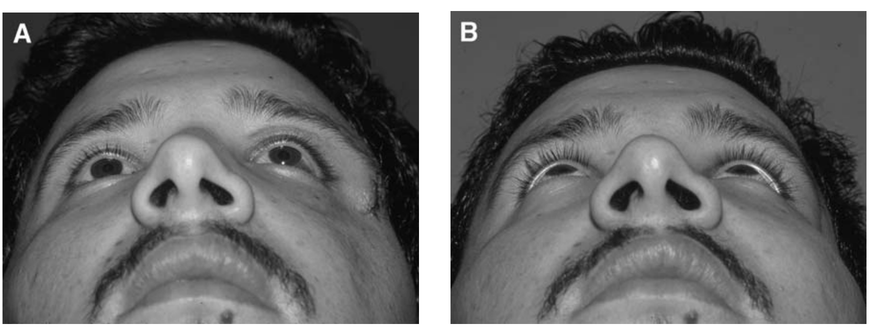

Fig. 7. (*A*) Preoperative photograph of a patient with a complex zygoma fracture. Severe decrease in malar prominence projection and increased facial width can be appreciated. (*B*) Photograph several months following surgery shows restoration of normal facial topography. The arch component of four-point zygoma fracture repair was performed using the endoscopic technique. (*From* Czerwinski M, Lee C. Traumatic arch injury: indications and an endoscopic method of repair. Facial Plast Surg 2004;20(3):231–8, with permission.)

Discussion

The reliable form and strategic position of the zygomatic arch make it a valuable landmark in midfacial trauma management [8,9]. In isolated arch fractures, its repair restores lateral contour of the face and prevents subsequent displacement caused by reinjury or pull by the masseter muscle. In complex fractures of the zygoma, restoration of arch anatomy is an essential guide to recreating preinjury malar prominence projection and transverse facial width. In Le Fort III-level fractures, rigid arch repair is the most stable point of fixation that anchors the mobile maxillary dentition to the skull base. The relative importance of arch repair increases as the complexity of trauma rises, being most important in Le Fort III injuries and least so in isolated fractures.

Open zygomatic arch repair has been used infrequently, mainly because traditional access to this structure is fraught with undesirable sequelae, namely: alopecia, loss, of scalp sensation posterior to the incision, excessive blood loss, temporal hollowing and potential injury to the frontal branch of the facial nerve [4]. Thus for many years, the standard of anatomic reduction and rigid internal fixation used in facial trauma management did not apply to the arch. The authors believe the endoscopic approach allows the surgeon to fully appreciate the role of zygomatic arch in facial fracture management without having to suffer the consequences of coronal access. The endoscope-assisted approach necessitates only small, well-concealed incisions and allows in situ reduction and fixation under direct, magnified visualization. The authors encourage the use of the endoscope-assisted zygomatic arch repair in Le Fort III, complex zygoma, and isolated arch fractures, all of which previously had been considered to be indications for a coronal incision.

The endoscopic method of zygomatic arch repair does have some disadvantages. It requires the acquisition of a different set of surgical skills. This technical challenge arises, because the separation in the usual hand-eye coordination results in the loss of tactile perception. In addition, perception of depth is lost as the three-dimensional image is reformatted on a flat screen. Furthermore, there is an associated steep learning curve resulting in initially long operative times. Finally, purchase of required surgical instruments and electronic devices represents a significant initial expense.

Being aware of its difficulties, the authors believe endoscope-assisted zygomatic arch repair represents a significant advance in midfacial trauma management. In the future, implementation of specialized training programs into surgical program curricula and further improvements in endoscopic instruments will promote this technique further.

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