The Effectiveness of 1-Point Fixation for Zygomaticomaxillary Complex Fractures

Ji Heui Kim, MD, PhD; Jun Ho Lee, MD, PhD; Seok Min Hong, MD, PhD; Chan Hum Park, MD, PhD

Objectives: To introduce the surgical technique of 1-point fixation at the zygomaticomaxillary buttress (ZMB) and to verify its effectiveness using 3-dimensional computed tomography (3D CT).

Design: Case series with chart review.

Setting: Academic tertiary care medical center.

Patients and Methods: The study included 29 patients who underwent 1-point fixation at the ZMB for zygomaticomaxillary complex fractures without comminution of lateral orbital rim fractures. Preoperative and postoperative 3D CT scans were obtained to evaluate vertical and horizontal changes of the zygoma, which were analyzed according to preoperative 3D CT findings.

Results: The ZMB area was fixed with a resorbable system in 26 patients and with a metal system in 3 patients. After surgery, the mean vertical change improved from 1.28° to 0.58° (P < .001), and the mean horizontal change improved from 1.71° to 0.92° (P < .001). Postoperative vertical movement of the zygoma was not significantly affected by comminution of the inferior orbital wall, zygomaticofrontal process displacement, or comminution of the ZMB area and zygomatic arch (P > .05 for each). However, comminution of the ZMB area had an adverse effect on horizontal movement of the zygoma (P = .03). Complications after surgery included facial cellulitis associated with acute sinusitis in 1 patient, who was treated successfully. No patient required revision reduction because of facial deformity.

Conclusion: Our findings suggest that 1-point fixation at the ZMB provides sufficient stability of the zygomaticomaxillary complex without comminuted fractures of the lateral orbital rim.


The Zygomaticomaxillary complex (ZMC) is an important functional and aesthetic landmark of the mid-face and provides the prominent cheek structure. Unfortunately, it is very vulnerable to injury because of its prominent convexity. Trauma to the ZMC represents 45% of all midface fractures. A popular method for ZMC fracture repair is open reduction and internal fixation, which results in a more symmetrical ZMC position because direct exposure of the fracture allows visual alignment, and the wide exposure permits better mobilization of the displaced complex and use of a reduction force vector. Stability and exactness of reduction are still debated in terms of the number of plates applied to the facial buttress. Some authors have recommended open reduction and multiple-plate fixation for ZMC fractures to avoid facial asymmetry caused by delayed disfigurement. Other authors have proposed that 1-point fixation is sufficiently rigid when the fracture is not comminuted and 3-point alignment is achieved.

The advantages of 1-point fixation are that the procedure does not require another skin incision with associated scarring and that the operating time is shorter than that of multiple-plate fixation. Herein, we describe our surgical technique of 1-point fixation at the zygomaticomaxillary buttress (ZMB) and its results in patients with ZMC fractures without comminuted fractures of the lateral orbital rim. We also suggest guidelines for application of this approach using orthogonal measurements of zygoma displacement.
bital rim were treated using 1-point fixation at the ZMB by the same surgeon (C.H.P.) between September 2005 and July 2009. Patients were excluded if they had congenital craniofacial anomalies and previous craniofacial injuries (skeletal or soft tissue) or operations; if they had a fracture of the other ZMC or an associated Le Fort maxillary fracture; if they had a follow-up period of less than 6 weeks; or if their postoperative 3-dimensional computed tomographic (3D CT) findings were not available. Finally, 29 of the 43 patients were included in this study.

Their medical records were reviewed for the following data: age, sex, medical and surgical history, cause of trauma, associated facial fractures, abnormal eye signs before surgery, exploration time, preoperative and postoperative 3D CT findings (ie, comminution and displacement of inferior orbital rim, zygomaticofrontal [ZF] buttress, ZMB, and zygomatic arch), operative findings, and complications. Eye movement, diplopia, and other ophthalmologic signs and symptoms were routinely examined by ophthalmologists before and after surgery. The study was approved by the institutional review board of Chuncheon Sacred Heart Hospital, Chuncheon, South Korea.

SURGICAL TECHNIQUE

All operations were performed in the operating room with the patient under general anesthesia. An incision was made 0.5 cm above the gingivobuccal sulcus. After the submucoperiosteal flap was elevated, fracture sites were identified. Traction was applied until the inferior and lateral orbital rim and buttress were aligned under direct vision using a Langenbeck elevator or retractor underneath the zygomatic body in an anterolateral direction (Figure 1A). The alignments of the inferior orbital rim, ZF buttress, and zygomatic arch were estimated by ultrasonography (Z-one; Zonare Medical Systems). If the remaining displacement was identified by ultrasonography, an elevator was accurately placed and applied to reduce the bone fragments to the correct anatomical position with ultrasonography. The ZMB was immobilized with self-reinforced poly(l/DL-lactide) polymer microplates and screws (SR-PLDLA; ConMed Linvatec Biomaterials) or a titanium minimicro system (Solco Intermed) (Figure 1B). A splint (Aqua Splint; Aladin Sabbagh) was applied to support the bone fragment externally.

OUTCOME MEASUREMENTS

The patients underwent 3D CT (Somatom Sensation 64; Siemens Medical Solutions) before surgery to evaluate the type and extent of the fracture and at 2 to 6 months after surgery to assess successful reduction. Multidetector CT was performed in the axial position using a 3-mm section thickness, and the coronal and 3D views were then reconstructed using a computer program. The 2 preoperative and postoperative orthogonal aspects were measured. Vertical change (VC), which represents the movement of the bilateral infraorbital rim line, and horizontal change (HC), which represents the movement of the bilateral anterior margin of the fossa temporalis line, in the zygoma were measured on 3D views to assess the effectiveness of 1-point fixation at the ZMB (Figure 2).5

STATISTICAL ANALYSIS

The Wilcoxon signed rank test was used to compare preoperative and postoperative VC and HC. Postoperative VC and HC according to preoperative 3D CT findings were compared using the Mann-Whitney test. \( P < .05 \) was considered significant. Data analyses were performed using SPSS for Windows, version 12.0 (SPSS Inc).

RESULTS

The patient population consisted of 24 males and 5 females, with a mean age of 45.3 years (range, 16-87 years). Two patients had diabetes, and 1 patient had received chemotherapy for esophageal cancer. One patient had undergone closed reduction of a contralateral zygomatic arch via the Gillies approach 6 months earlier, and his preoperative 3D CT revealed a faint fracture line without definite displacement of the zygomatic arch.

The most common cause of ZMC fracture was falls (45%), followed by traffic accidents (38%), sports injuries (14%), and assault (3%). A nasal bone fracture was
present in 1 patient, and an orbital medial wall fracture without extraocular muscle entrapment was present in 2 patients. Partial limitation of extraocular muscle movement seen with the upper gaze of the lesion side occurred in 2 patients, but they did not complain of diplopia. Exploration was performed 1 to 18 days (mean [SD], 8.9 [4.6] days) after trauma.

Preoperative 3D CT scans did not document significant displacement of the infraorbital rim in any patients, but a comminuted fracture along the infraorbital rim, with minimal herniation of orbital fat and without evidence of muscle entrapment, was observed in 4 patients (14%). None of these patients had radiologic evidence of ZF process comminution, but 5 patients (17%) showed minimal displacement of the ZF buttress. Eighteen patients (62%) had evidence of comminution in the ZMB area, which was fixed with more than 2 plates. Six patients (21%) showed evidence of comminution at the zygomatic arch.

The ZMB area was fixed with resorbable plates of various shapes, lengths, and thicknesses and with screws of corresponding sizes and weights in 26 patients. Among them, straight plates measuring $5.5 \times 20.5 \times 1.0$ mm with 4 holes were used in 15 patients (58%), straight plates measuring $5.5 \times 30.5 \times 1.0$ mm with 6 holes were used in 16 patients (62%), curved plates measuring $5.5 \times 30.5 \times 1.0$ mm with 6 holes were used in 5 patients (19%), and right-angled plates measuring $5.5 \times 27 \times 1.0$ mm with 6 holes were used in 5 patients (19%). In 3 patients, a metal plate and screw system was used to fix the ZMB area; the systems consisted of straight plates measuring $4 \times 24 \times 0.8$ mm with 6 holes, straight plates measuring $4 \times 16 \times 0.8$ mm with 4 holes, or straight plates measuring $3 \times 31 \times 0.5$ mm with 8 holes and curved plates measuring $3 \times 30 \times 0.5$ mm with 8 holes.

The mean VC improved from 1.28° to 0.58° ($P < .001$), and the mean HC improved from 1.71° to 0.92° ($P < .001$) after 1-point fixation at the ZMB (Figure 3). Postoperative VC was not significantly influenced by comminution of the inferior orbital wall, ZF displacement, or comminution of the ZMB area and zygomatic arch ($P > .05$). However, postoperative HC was adversely affected by comminution of the ZMB area ($P = .03$) (Table). Postoperative complications included facial cellulitis associated with acute sinusitis in 1 patient, who was successfully treated with endoscopic sinus surgery and intravenous ampicillin-sulbactam (3 g 4 times a day for 10 days). No patient required revision open reduction and internal fixation because of remnant facial deformity during the follow-up period.

**COMMENT**

This study demonstrated that 1-point fixation at the ZMB through a gingivobuccal incision was effective for tripod fractures without comminution of lateral orbital rim fractures. If the lateral and inferior orbital walls are adequately reduced, this surgical technique results in a successful outcome. To avoid long-term aesthetic, sensory, or ocular consequences, stable reduction is essential in the treatment of ZMC fractures. However, unsolved issues remain, such as recommended surgical procedure and indications for a particular procedure. The treatment should be as minimally invasive as possible to avoid multiple surgical approaches, consequent potential infections, additional scars, and nerve palsy and should provide precise physical stability of the zygoma. The number and location of miniplates for fixation are controversial because they depend on the fracture anatomy, extent, and amount of displacement. Davison et al stated that 1-point fixation produced unstable fixation in their in vitro studies, and they proposed that 2-point fixation using a miniplate alone conferred a degree of stability comparable with most methods of 3-point fixation, regardless of the site at which the miniplates were applied. Other authors routinely expose
Figure 3. A 26-year-old man with a right tripod fracture due to a sport injury. A, The preoperative photograph (top) shows a mildly depressed right malar deformity, and the preoperative 3-dimensional computed tomogram (3D CT) (bottom) reveals a comminuted fracture of the zygomaticomaxillary buttress and minimal displacement of the fractured zygomatic arch. The zygomaticofrontal suture is fractured without displacement. B, The postoperative photograph (top) and the postoperative 3D CT (bottom) show good contour and favorable malar alignment after 1-point fixation at the zygomaticomaxillary buttress.

Table. Analysis of Postoperative Changes in Zygoma Movement According to Preoperative 3-Dimensional Computed Tomographic (3D CT) FindingsMode

<table>
<thead>
<tr>
<th>Preoperative 3D CT Findings</th>
<th>Postoperative VC, °</th>
<th>Postoperative HC, °</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comminution of the inferior orbital wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None (n = 25)</td>
<td>0.57 (0.46)</td>
<td>0.91 (0.71)</td>
</tr>
<tr>
<td>Comminution (n = 4)</td>
<td>0.60 (0.57)</td>
<td>0.99 (1.14)</td>
</tr>
<tr>
<td>P-value</td>
<td>&gt;.99</td>
<td>.60</td>
</tr>
<tr>
<td>Displacement of ZF process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None (n = 24)</td>
<td>0.60 (0.49)</td>
<td>0.88 (0.74)</td>
</tr>
<tr>
<td>Displacement (n = 5)</td>
<td>0.46 (0.33)</td>
<td>1.13 (0.90)</td>
</tr>
<tr>
<td>P-value</td>
<td>.63</td>
<td>.59</td>
</tr>
<tr>
<td>Comminution of ZMB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None (n = 11)</td>
<td>0.61 (0.48)</td>
<td>0.53 (0.30)</td>
</tr>
<tr>
<td>Comminution (n = 18)</td>
<td>0.56 (0.46)</td>
<td>1.16 (0.86)</td>
</tr>
<tr>
<td>P-value</td>
<td>.55</td>
<td>.03</td>
</tr>
<tr>
<td>Comminution of zygomatic arch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None (n = 23)</td>
<td>0.53 (0.46)</td>
<td>0.92 (0.76)</td>
</tr>
<tr>
<td>Comminution (n = 6)</td>
<td>0.77 (0.44)</td>
<td>0.94 (0.81)</td>
</tr>
<tr>
<td>P-value</td>
<td>.21</td>
<td>.98</td>
</tr>
</tbody>
</table>

Abbreviations: HC, horizontal change; VC, vertical change; ZF, zygomaticofrontal; ZMB, zygomaticomaxillary buttress.

*All values other than P values are presented as mean (SD) and are reported in degrees.
the infraorbital rim and perform multiple osteosyntheses or even expose all or nearly all of the fracture lines. On the other hand, Hwang suggested that 1-point fixation of tripod fractures through a lateral brow incision can apply to cases with minimal or moderate displacement of the infraorbital rim in a tripod fracture, no ocular signs of diplopia or enophthalmos, and comminuted infraorbital rim fractures when internal fixation is difficult. However, because the ZMB plays a key role in withstanding contraction of the masseter muscle and supporting zygoma, rigid fixation at the ZMB is important in the treatment of tripod fractures. Tarabichi reported successful results with transsinus reduction through the comminuted anterior wall of the sinus and 1-point fixation of malar fractures and pointed out that in vitro studies are misleading because of the absence of serration along the orbital rim and disregard of the roles of the superficial musculoaponeurotic system, uninterrupted peristeum, and skin in stabilizing a fractured zygoma. Fujioka et al suggested that 1-point fixation at the zygomaticomaxillary compartment was sufficiently rigid in their in vivo study when the fracture was not comminuted and 3-point alignment was achieved. Our technique has some advantages that differ from those of previous reports. First, because a skin incision is unnecessary, the surgeon does not need to be concerned about a facial scar, which can shorten the operating time. Second, we used ultrasonography to evaluate alignment of the inferior orbital wall, ZF buttress, and zygomatic arch. Ultrasonography is a valuable visualization tool for both diagnosis and treatment of facial bone fractures. When the remaining displacement is identified by ultrasonography, a repositioning instrument can be accurately positioned beneath the bone fragments and applied to restore the correct anatomical position with ultrasonography. Therefore, if it is not difficult to reduce displacement of the ZF process and a comminuted fracture of the infraorbital rim and zygomatic arch using ultrasonography, 1-point fixation at the ZMB area should be sufficiently stable for tripod fractures. If the lateral orbital rim is comminuted, 2-point fixation should be performed not only in ZMB but also in ZF compartment added lateral canthal incision. In this study, when there was comminution of the ZMB area, postoperative HC showed poor results. However, the patients were satisfied with the postoperative cosmetic outcome. Also, this problem could not have been solved by multiple-point fixation.

In conclusion, we recommend the following indications for 1-point fixation at the ZMB via a gingivobuccal incision: (1) no comminution of lateral orbital rim fractures or displacement of the ZF process, and (2) comminuted fragments of the infraorbital rim and zygomatic arch when reduction is not difficult with ultrasonography.

Submitted for Publication: May 8, 2012; final revision received June 15, 2012; accepted July 13, 2012.

Correspondence: Chan Hum Park, MD, PhD, Department of Otolaryngology—Head and Neck Surgery, Chuncheon Sacred Heart Hospital, Hallym University College of Medicine, 153, Kyo-Dong, Chuncheon, 200-704, South Korea (hlpch@paran.com).

Author Contributions: Drs Kim and Park had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Kim, Lee, Hong, and Park. Acquisition of data: Kim, Lee, Hong, and Park. Analysis and interpretation of data: Kim and Park. Drafting of the manuscript: Kim. Critical revision of the manuscript for important intellectual content: Kim, Lee, Hong, and Park. Statistical analysis: Kim, Lee, and Hong. Obtained funding: Park. Study supervision: Park.

Financial Disclosure: None reported.

Funding/Support: This research was supported by a grant from Bio-industry Technology Development (111100-03-1-SB010), Ministry for Food, Agriculture, Forestry, and Fisheries, and BioGreen 21 Program (No. PJ000951062012), Rural Development Administration, Republic of Korea.

Role of the Sponsors: The sponsor had a role in the preparation of the manuscript.

REFERENCES