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Experimental evaluation of relapse-risks in operated zygoma fractures

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Abstract

Objectives: Prevention of relapse, or postoperative dislocation, of the fixed zygoma is necessary to achieve optimal results in the treatment of zygoma fractures. Assuming that the occurrence of intensified stresses on mastication at the screw–bone interface (SBI) constitutes the essential cause of the relapse, we evaluated the stresses for three different fixation methods—fixation at the frontal process (FP), inferior orbital rim (IOR), and zygomatico-maxillary buttress (ZMB).
Methods: We used 10 computer-aided design (CAD) models simulating zygoma fractures in the experiment. For each CAD model, we fixed the fractured zygoma with four screws and one mini-plate at the FP, IOR, or ZMB. After applying a 5.5 kg force simulating mastication, we calculated the intensity and distribution patterns of the stresses occurring at the SBIs of the fixation screws using the finite element method. Thereby, we evaluated dynamic stability of the fixed zygoma for each of the three fixation methods.
Results: Greater stresses occur at the SBIs with IOR fixation than at those with FP and ZMB fixation. Although the stresses occurring at the SBIs on mastication demonstrated evenly distributed patterns with the FP and ZMB fixation, the stresses demonstrated concentration on one screw with the IOR fixation.
Conclusions: The fixed zygoma is more likely to cause relapse with the IOR fixation than with the FP or ZMB fixation. Hence, in performing zygoma fixation at the IOR, care should be taken to minimize the likelihood of postoperative relapse that is caused by skewed distribution of the stresses on the fixation screws.

Keywords: Zygoma; Fracture; Fixation; Screw; Stress; Mastication

1. Introduction

Zygoma fracture is one of the traumas that head and neck surgeons frequently encounter in their daily practices [1–3]. Surgical treatment is necessary for cases in which the fractured zygomae present dislocation. The basic principle of surgical treatment for zygoma fracture is to place the fractured zygoma at the correct position and fix it there [4–7]. In some cases, however, the fixed zygomae dislocate as time passes. This complication is termed ‘‘relapse’’ [8]. Since occurrence of relapse produces unnaturally flattened appearances of the patients’ cheeks, preventive measures for relapse should be taken in performing treatment of zygoma fractures.

Then, what measures should we take to prevent the relapse? The fixed zygomae – supported by only fixation screws and plates – are unstable until they merge with the surrounding bones by wound healing. Under this unstable condition, the fixed zygoma slightly deviates downward as the masseter muscles function during mastication. Due to the deviation of the fixed zygoma, intensified stresses occur at the screw–bone interfaces (SBIs) of the fixation screws. The

Abbreviations: FP, frontal process; IOR, infra-orbital region; ZMB, zygomatico-maxillary buttress; SBI, screw–bone interface.

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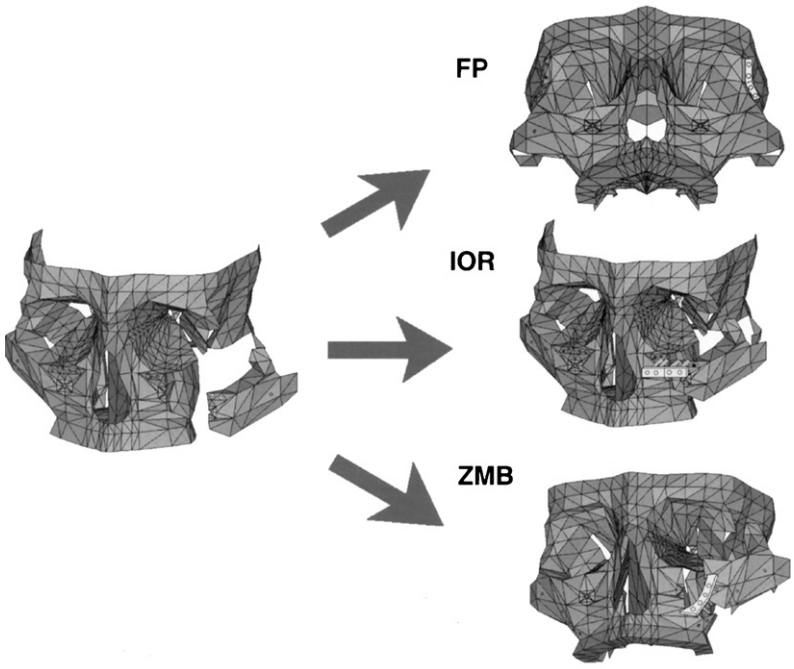

Fig. 1. For each of the 10 zygoma fracture models, the fractured zygoma was independently fixed at one of the three sites the frontal process (FP), the infra-orbital region (IOR), and the zygomato-maxillary buttress (ZMB). Thus, three model groups 10 models for each of the three fixation sites were produced. The three groups were named the FP fixation group, the IOR fixation group, and ZMB the fixation group, respectively.

constant occurrence of the intensified stresses induces bone absorption there, which eventually leads to loosening of the fixation screws. This is the etiology of the relapse.

Therefore, to lower the risk of relapse, we should take measures to avoid the occurrence of intensified stresses at the SBIs. To achieve this purpose, we first have to understand the patterns stresses present at the SBIs during mastication. We conducted the present study in order to achieve this purpose.

2. Materials and methods

2.1. Production of zygoma fixation models

After collecting CT data of 10 actual skulls, we produced a computer-aided design (CAD) model of each skull using its CT data on a workstation (Dell Inspiron 6000, Dell Co., Round Rock, TX, USA). Then we separated the left side zygoma from each skull's CAD model to produce 10 zygoma fracture models. For each of the 10 zygoma fracture models, we fixed the separated zygoma using four screws and one mini-plate. Three different fixation sites – the frontal process (FP), infra-orbital region (IOR), and zygomato-maxillary buttress (ZMB) – are commonly used for the zygoma fixation. Therefore, we performed the fixation for each of the 10 models at each of these three sites, separately. Thus, three model groups (each composed of 10 models) were produced. Depending on the fixation site, we termed these groups the FP fixation group, the IOR fixation group, and the ZMB fixation group, respectively (Fig. 1). We set the thickness of the fixation plate at 1 mm; we set the diameter of the fixation screws at 1.2 mm. Materials for the mini-plates and screws were assumed to be titanium. Of the two screws on the supporting side, the one close to the fracture line was termed the SC (S and C mean supporting and close, respectively) screw; the distant one was termed the SD (S and D mean supporting and distant, respectively) screw (Fig. 2). Of the two screws on the fractured zygoma, the one close to the fracture line was termed the FC (F and C mean fracture and close, respectively) screw; the distant one was termed the FD (F and D mean fracture and distant, respectively) screw.

SD screw: supporting side distant screw; SC screw: supporting side close screw; FC screw: fractured side close screw; FD screw: fractured side distant screw.

2.2. Loading

We applied loads simulating mastication on each zygoma fixation model. For each model, we gave zero displacements on the axial plane 2 cm above the upper rim of the orbit and on the coronal plane at the pterygoid process. Thereby we simulated immobilization of the skull at these sites. Then we applied a 5.5 kg force on the zygomatic arch of each model to simulate mastication (Fig. 3). The intensity of the force was set referring to Davidson's study [9].