Interdisciplinary Surgical Management of Multiple Facial Fractures With Image-Guided Navigation

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Purpose: To evaluate the effectiveness of interdisciplinary surgical management of multiple facial fractures with image-guided surgical navigation.

Patients and Methods: From 2011 through 2014, 36 patients with multiple facial fractures were enrolled in the study. With individual virtual 3-dimensional (3D) modeling, interdisciplinary planning and surgical simulation were carried out on an Accu-Navi software platform. Through an interactive collaboration among specialists, all patients underwent 1-stage open reduction under guidance of the navigation system. The outcome was assessed by superimposing the postoperative 3D computed tomographic (CT) model on the preoperative plan and clinical examination.

Results: Through the registration procedure, an accurate match between the actual intraoperative position and the CT images was achieved within a systematic error of 1 mm. The fractured bone segments were released and repositioned according to the preoperative plan and simulation with the aid of instrument- and probe-based navigation. All patients underwent uneventful healing without serious complications. Postoperative assessment of surgical intervention showed a quantitative discrepancy less than 2 mm (1.49 ± 0.27), showing a satisfactory concordance.

Conclusion: In the interdisciplinary surgical management of multiple facial fractures, image-guided surgical navigation, including preoperative planning, surgical simulation, postoperative assessment, and computer-assisted navigation, proved an optimal strategy and valuable option for this potentially complicated procedure.

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Multiple facial fractures often present with complicated clinical features. Surgical treatment in the management of such fractures becomes challenging owing to frequently missing references for the reduction of facial compartments and the complexity of intractable facial vital organs.[1] Furthermore, they are often accompanied by craniocerebral injuries and life-threatening systemic failures, leading to delayed management, followed by perpetual malunion and soft tissue shrinkage.[2] Such characteristics of multiple facial fractures have raised the necessity for interventions by various specialists.[3,4]

Although *multidisciplinary* simply refers to an approach in which multiple health care providers treat patients independently, an *interdisciplinary* team approach aspires to a more profound level of collaboration, in which constituents of different backgrounds combine their knowledge of mutually complete, different levels of planned care.[5] Well-coordinated collaboration across surgeons has shown the potential for a single-stage procedure, cost-effective patient care, and an emphasis on comprehensive management, which are essential to meet the complicated surgical challenges of multiple facial fractures.[6,7]

With the development of modern digital imaging technology, computer-assisted simulation and image-guided navigation have played ever-increasing roles in oral and maxillofacial surgery.[8–10] These approaches have shown potential feasibility for multidisciplinary team collaboration, allowing the exchange of feedback among the involved doctors and permitting optimized coordinate-directed treatment.[11] Because there are few studies on interdisciplinary craniomaxillofacial management, the authors describe their experience of the interactive role of image-guided surgical navigation for interdisciplinary surgical management of multiple facial fractures.

Patients and Methods

PATIENTS AND STUDY DESIGN

Thirty-six patients (30 men and 6 women) presenting with multiple facial fractures were admitted to the Department of Oral and Craniomaxillofacial Science, Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China, from July 2011 through December 2014. Their ages ranged from 17 to 64 years (average age, 44.1 yr), and the patients had a history of trauma 7 days to 17 years before surgical interventions. Patients' clinical characteristics are presented in Table 1. Access to patients' medical records and the use of image-guided surgical navigation were approved by the institutional ethics committee.

PREOPERATIVE PLANNING AND SURGICAL SIMULATION

The module and flow diagram of interdisciplinary surgical management are depicted in Supplementary Figures 1 and 2. As navigation positioning markers, 5 titanium screws were implanted in the maxillary alveolar bone. The preoperative radiologic examinations involved thin-cut (0.625-mm), spiral computed tomographic (CT) scans (Light Speed 16, General Electric, Fairfield, CT) for all patients. Individual Digital Imaging and Communications in Medicine (DICOM; version 3.0) protocol CT datasets were obtained and transferred to a Windows-based computer workstation with Accu-Navi software (Multifunctional Surgical Navigation System, Shanghai, China) to convert the DICOM data into a proprietary format.

The first role of computer-assisted navigation for interdisciplinary approach began with the preoperative planning and surgical simulation of the virtual 3-dimensional (3D) skull model. According to the mirrored segments, the involved surgeons could manipulate the fractured segments freely while observing the virtual and real anatomic structures that were displayed in different colors (Fig 1, Supplementary Fig 3). Through this process, surgical plans, including the sequence of the surgery for each patient, were discussed by the interactive team, including a radiologist. Considering the expertise of each specialist, especially the neurosurgeon's knowledge of cranial fractures, including fractures of the skull base, frontal sinus, and ethmoid with or without neurologic symptoms, cerebrospinal fluid leakage, and the ophthalmologist's viewpoint regarding ocular injury, optic neuropathy, and ocular dysmotility, image-guided surgical navigation was used to achieve a better prognosis and avoid complications.

For patients with unilateral involvement, the median sagittal plane was used as a reference plane for mirroring and superimposing the unaffected side onto the fractured side. For patients with bilateral involvement, the harmonious appearance of the facial structures and existing anatomic landmarks were considered in the simulation and creation of the virtual surgical template. Once the surgical simulation was completed, the original and virtual datasets were imported into the intraoperative navigation system. When the discrepancy between the actual and ideal positions was less than 1 mm, the green reference points would turn red, synchronized by a beep sound, indicating that the surgical operation had matched the preoperative simulation.

REGISTRATION AND IMAGE-GUIDED SURGICAL NAVIGATION

Point registration was applied in these multiple fractures cases, including the use of fiducial markers