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Outcome Study of Computer-Aided Surgical Simulation in the Treatment of Patients With Craniomaxillofacial Deformities

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Purpose: The purpose of this study was to determine whether the surgical outcomes achieved with computer-aided surgical simulation (CASS) are better than those achieved with traditional methods.

Materials and Methods: Twelve consecutive patients with craniomaxillofacial (CMF) deformities were enrolled. According to the CASS clinical protocol, a 3-dimensional computer composite skull model for each patient was generated and reoriented to the neutral head posture. These models underwent 2 virtual surgeries: 1 was based on CASS (experimental group) and the other was based on traditional methods 1 year later (control group). Once the 2 virtual surgeries were completed, 2 experienced oral and maxillofacial surgeons at 2 different settings evaluated the 2 surgical outcomes. They were blinded to the planning method used on the virtual models and each other's evaluation results. The primary outcome was overall CMF skeletal harmony. The secondary outcomes were individual maxillary, mandibular, and chin harmonies. Statistical analyses were performed.

Results: Overall CMF skeletal harmony achieved with CASS was statistically significantly better than that achieved with traditional methods. In addition, the maxillary and mandibular surgical outcomes achieved with CASS were significantly better. Furthermore, although not included in the statistical model, the chin symmetry achieved by CASS tended to be better. A regression model was established between mandibular symmetry and overall CMF skeletal harmony.

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Conclusion: The surgical outcomes achieved with CASS are significantly better than those achieved with traditional planning methods. In addition, CASS enables the surgeon to better correct maxillary yaw deformity, better place proximal/distal segments, and better restore mandibular symmetry. The critical step in achieving better overall CMF skeletal harmony is to restore mandibular symmetry.

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Craniomaxillofacial (CMF) surgery involves the correction of congenital and acquired conditions of the head and face. Each year throughout the world, many patients require surgical correction for these deformities.[1-7] Success of CMF surgery depends not only on the technical aspects of the operation but to a larger extent on the formulation of a precise surgical plan.[8-15] Unfortunately, the traditional planning methods, ie, prediction tracings and surgical simulation on stone dental models, have remained mostly unchanged over the past 50 years.[9,10,12,16] They present significant limitations and are often inadequate for the treatment of patients with complex CMF deformities.[12-14,16,17] Each of these limitations can result in a poor surgical outcome.[17] In isolation, these problems may be minor, but when added together they can be significant.

To rectify these problems, surgeons have begun to use 3-dimensional (3D) computer-aided surgical simulation (CASS) to plan complex CMF surgery.[17] With CASS, the surgeon is able to perform "virtual surgeries" and create a 3D prediction of surgical outcomes. To date, many CMF procedures have been planned using the CASS system, including maxillofacial surgery,[12,13] craniofacial surgery,[18,19] trauma,[19,20] distraction osteogenesis,[16] reconstruction after tumor ablation,[19,21] and temporomandibular joint reconstruction.[22] Investigators have documented the clinical feasibility,[10] accuracy,[23] and cost-effectiveness[24] of the CASS system developed in the surgical planning laboratory. However, the "better surgical outcomes" achieved with the CASS method are based only on clinical observation. It has not been quantitatively documented whether CASS has produced a better surgical outcome. Therefore, the purpose of this study was to determine whether surgical outcomes achieved with CASS are better than those achieved with traditional methods.

Materials and Methods

Twelve consecutive patients with CMF deformities seen from July 2006 through June 2008 were enrolled in the study. Inclusion criteria were *1)* patients who were scheduled to undergo double-jaw orthognathic

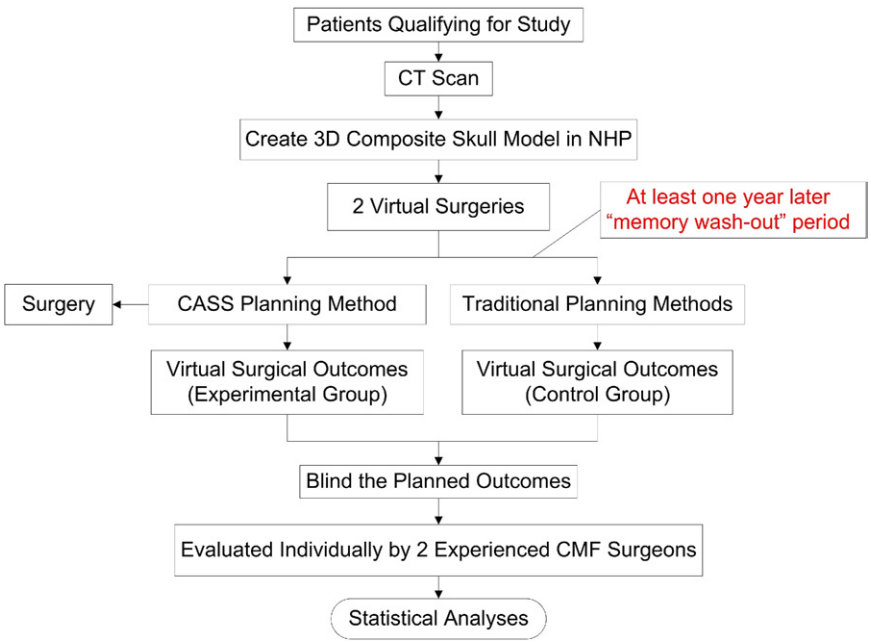

FIGURE 1. Study design. CASS, computer-aided surgical simulation; CMF, craniomaxillofacial; NHP, neutral head posture.
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