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# Computer-Assisted Orthognathic Surgery: Advantages and Clinical Application

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Orthognathic surgery is a surgical procedure to treat facial deformities caused by cranio-maxillofacial developmental abnormalities, trauma or tumor. It involves osteotomy of jaw bones to correct facial disharmony as well as to establish good occlusal relationship [1]. Conventionally, a "classic" surgical protocol may involve clinical examination, cephalometric analysis and anatomically articulated plaster cast of the dental arches. The latter is used to plan skeletal movements and to fabricate splints, which will be used to replicate those movements during surgery [2].

Although evolving over decades, surgical planning to obtain desired effect and accuracy still remains difficult and time-consuming. The dental-maxillofacial bones are anatomically complex structures and should be moved and repositioned precisely within three-dimensional space. Prediction of this movement is invisible and the accuracy largely depends on the experience of orthognathic surgeon and orthodontist involved. Besides, interaction with the patients and laboratory work for surgical splint construction are far more time-consuming than the surgery itself [2].

Advances in computing have resulted in the use of computers in every aspect of our daily life, and there is no exception in medical field. Computer technology has been recognized for its potential in simplifying this process. Computer-assisted surgical simulation provides the surgeon with a digital three-dimensional composite of the skull, soft tissues and dentition. Three-dimensional (3D) cephalometric analysis of both hard and soft tissue can be done by professional software. Osteotomy and reposition of the segmented jaw bones then can be performed virtually on the screen, which allows surgeon and patient to have a reasonable preview of post-operative outcome [3]. Computer-assisted design and computer-assisted manufacturing (CAD/CAM) technology, together with the surgical navigation system, can help to generate surgical splint and guide template in order to transfer the virtual plan to actual surgical procedure [4,5]. Generally speaking, computer-assisted orthognathic surgery provides a number of significant benefits in: (1) evaluation and diagnosis, (2) simulation and surgical planning, and (3) education of the patient and professionals [3].

These advantages are further detailed below:

3D cephalometric analysis and diagnosis benefit from the using of advanced imaging modalities such as CBCT and intraoral scanning. Comparing with the conventional CT, CBCT presents advantages such as higher image quality, smaller radiation doses, and the possibility to keep natural head position during scanning. The major disadvantage of CBCT is the image distortion where metallic brackets exist. But this distortion can be diminished by replacing the dental arch segment into digitized dental cast derived from intraoral scanning or plaster cast scanning. Fusion of CBCT and digital cast shows better accuracy and higher reproducibility, which is important in computer-assisted simulation and surgical planning. Facial photogrammetry additionally improves the image quality of soft tissue which can hardly be evaluated using 2D radiographs.

The virtual 3D model in professional software allows surgeons to perform several 3D cephalometric analyses. Image superimposition errors in 2D cephalometric radiographs are avoided. The anatomical structures and occlusal contacting points can be visualized, thus surgeons can simulate osteotomy and segmented bone movement on computer prior to surgery, trying possible plans and evaluating outcomes, with no risk to the patient. Surgical splint or guide template can then be designed and manufactured using CAD/CAM or 3D print technology. This is beneficial for surgeons in saving time during surgery analysis, treatment planning, model surgery, and construction of resin splints [6,7]. The accuracy can also be guaranteed since the literature provides strong indications that computer-assisted simulation and planning is more accurate than classic methods [1,8,9].

Computer-assisted simulation is ideal for orthognathic surgery because both the skull and the overlying soft tissues, and the upper airway if necessary, can be precisely simulated and visualized at the same time [3]. That gives surgeon, orthodontist and patient a chance to sit together in front of a screen to watch the proposed outcome. The treatment plans and available options are also described at the same time, allowing the orthodontist and the patient to participate more in the treatment decision. What's more, the education of other professionals, residents and students is facilitated by using this type of presentation. This ability of preoperatively simulating and planning the orthognathic surgery provides a better surgical result, with potentially less time and expense in the operating room, greater surgical accuracy, and less chance of surgical revision [1,2,10].

In our clinical practice, computer-assisted orthognathic surgery has gradually become a routine procedure for every patient. Patients are generally referred by their orthodontist for an initial orthognathic surgery consultation. Clinical evaluation of a patient's skeletal, dental, and soft tissue problems is involved in this consultation. A preliminary treatment plan is discussed with the patient and his/her orthodontist. Preoperative CT or CBCT scanning is then performed and DICOM (Digital Imaging and Communications in Medicine) images are imported into Mimics 19.0 (Materialise, Leuven, Belgium). Different components of the skull are segmented (mandible, maxilla, skull) using a thresholding method. The plaster casts of both preoperative occlusion and final occlusion are scanned with a high resolution optical scanner. This step can also be substituted for intraoral scanning. These casts were registered to the corresponding upper and lower jaws via point-based registration to form composite models of the maxilla and the mandible [2,11]. The virtual osteotomies were then performed according to the final occlusion and the preliminary treatment plan made in the initial consultation. The second appointment is scheduled 2 weeks before surgery. The modified surgical plan and postoperative

outcome simulation are shown to patient using the computer and 3D display. Patient can participate in the discussion and a final plan is decided in this appointment. The middle and final splints are then designed and precisely fabricated in biocompatible material using an Objet Connex 350 printer (Stratasys, Eden Prairie, MN, USA). The benefits of computers for assisting surgeons in the operating room include intraoperative planning according to the available advanced data, and surgical navigation to enhance the accuracy during operation. When compared with classic protocol, computer-assisted orthognathic surgery shows a better result with shorter time span, greater accuracy, and increased patients' satisfaction [1,3,12].

In conclusion, advancements in computer imaging have revolutionized the treatment of cranio-maxillofacial deformities. 3D evaluation and simulation can provide significant benefits for both professionals and patients. Continuing changes in computer science will be going on with the ever-increasing adoption of computer-assisted techniques in medicine field and, more specifically, in orthognathic surgery.

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