Case Report

The Innovation of Customized 3D Cutting Guide and Customized 3D Titanium Mesh Plate for Maxillectomy and Maxillary Defect Reconstruction in Thailand: Case Report

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In this article, we report the case of a 39-years-old man who presented with a rapidly growing mass at his right cheek. The result of investigations was compatible with non-ossifying fibroma with secondary aneurysmal bone cyst that involved the right zygoma, maxilla, and orbital floor. This patient was treated with CAD/CAM 3D virtual surgery that designed and developed a customized 3D cutting guide for maxillectomy, and a customized 3D titanium mesh plate for defect reconstruction. The procedure was clinically successful, and the patient was very satisfied with the functional and aesthetic outcomes. This surgical technology was adopted at our center in 2018 to treat patients requiring maxillofacial surgery and defect reconstruction, and this report profiles the first patient who had pathology at maxillary bone and treated with this surgical method.

Keywords: Customized 3D cutting guide, Customized 3D titanium mesh plate, Maxillectomy and maxillary defect reconstruction, Thailand

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Three-dimensional (3D) virtual surgery using computer-aided design and modeling (CAD/CAM) is a promising technique and a valuable method for diagnosis, treatment planning, and outcome evaluation, especially in patients that require complex craniomaxillofacial reconstruction[1-3]. The benefit of this computer-assisted surgical technique is that it allows the surgeon(s) to computer model the procedure and print the needed guide and reconstruction components before the first incision is made. This surgical method increases precision and reliability, decreases intraoperative time and complication, and it yields near perfect results[4,5]. The maxillary bone plays important roles in supporting all midface structures; facilitating speech, deglutition, and mastication; and, as a central component and determinant of facial structure and appearance. The goals of maxillary defect reconstruction include: 1) support of the eye globe, 2) closure of any opening between the orbit and the oronasal cavity, and 3) normalization of or improvement in facial contour and symmetry. Many reconstructive choices have been proposed to achieve optimal outcomes, including fibular osteocutaneous free flap, rectus abdominis musculocutaneous free flap, and vascularized bone grafts (fibula, scapular, and iliac)[6,7]. Recent advancements in CAD/CAM 3D virtual surgery allows surgeons to conduct better preoperative treatment planning, to perform more precise intraoperative resection and reconstruction, and to deliver significantly improved postoperative functional and aesthetic outcomes.

We adopted the use of CAD/CAM 3D virtual surgery at our center in 2018 for patients that require maxillofacial surgery and defect reconstruction. Here, we report our first experience using CAD/CAM 3D virtual surgery for maxillectomy and maxillary defect reconstruction using a customized 3D cutting guide and a customized 3D titanium mesh plate at Siriraj Hospital-Thailand's largest national tertiary referral center.

Case Report

A 39-years-old Thai male presented with a rapidly growing mass at his right cheek for 6 months. He has a past history of open fracture of the right zygomatic bone for which he underwent open reduction and internal fixation with wiring 15 years ago at another hospital. He denied having any postsurgical problems at the surgical site, including facial expression or masticatory function. Six months ago, he suspected the presence of a developing mass at his right cheek, but he had no pain, no numbness, and no inflammation. After presenting at our center for an evaluation, his physical examination revealed a well-circumscribed, hard consistency mass measuring approximately 4.5x3.5 cm at the right malar area (Figure 1). Neurological examination showed no numbness and no facial palsy. Ophthalmologic examination showed full extraocular muscle (EOM) function, no diplopia, 3 mm pupil reaction to light in both eyes, and grossly intact

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visual acuity and visual field. The interincisor gap was greater than 4 cm, there was no trismus, and occlusion was normal.

Radiological examination showed a bony expansile lesion at the right zygomatic body, discontinuation of the right infraorbital rim, decrease in size of the right maxillary sinus, and radiopaque metallic foreign bodies at the right zygoma (Figure 2). Tissue biopsy was performed and the pathology report showed non-ossifying fibroma with secondary aneurysmal bone cyst.

Preoperative contrast-enhanced computed tomography (CT) of the facial bone showed a thin-walled septated cystic lesion at the old fracture of the right zygoma with bony expansion (3.4 x 3.3 x 3.6 cm) and some intracystic hyperdense content. The lesion caused pressure effect to the lateral wall of the maxillary sinus, it involved the inferolateral wall of the right orbit, and it attached to the inferolateral aspect of right eye globe (Figure 3).

The decision was made to remove the tumor via maxillectomy using a Weber-Ferguson incision with subsequent reconstruction using a titanium mesh plate. Preoperative planning was commenced to create 3D images rendered from Digital Imaging and Communications in Medicine (DICOM) files derived from CT scan (via Avizo software (Thermo Fisher Scientific, MA, USA) and ANSYS software (Ansys Inc., PA, USA)). Preoperative 3D virtual surgical planning to create customized 3D cutting guides for maxillectomy and a customized 3D titanium mesh plate for defect reconstruction was performed step by step, starting with the determination of the surgical margin for tumor removal. Customized 3D cutting guides were then created that corresponded with the margin of tumor resection. After the tumor was excised, a customized 3D titanium mesh plate was designed using the adjacent bony contour and the contralateral normal facial bone as a reference template (Video 1, https://youtu.be/H9NOBnlBfR8). Finally, a preoperative 3D model, customized 3D cutting guides, and a customized 3D titanium mesh plate were printed (by selective laser melting using medical grade Ti-6Al-4V alloy (Meticuly Co., Ltd., Thailand)) and prepared for the operation (Figure 4).

The operation was performed under general anesthesia (GA) with endotracheal intubation. Weber-Ferguson incision was used to approach and explore the tumor. The customized 3D cutting guides were then applied

Figure 1. Pre-operative photos demonstrate the lumping mass and scar from previously traumatic injury and surgery at right malar area.

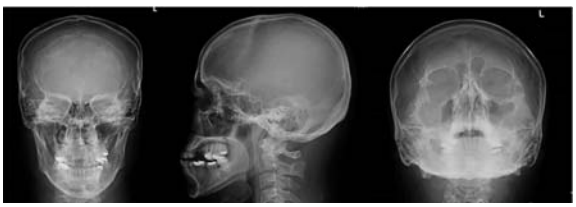

Figure 2. Pre-operative radiographic examination shows few surgical material at right zygoma with bony expansile lesion. Decrease in size of right maxillary sinus.

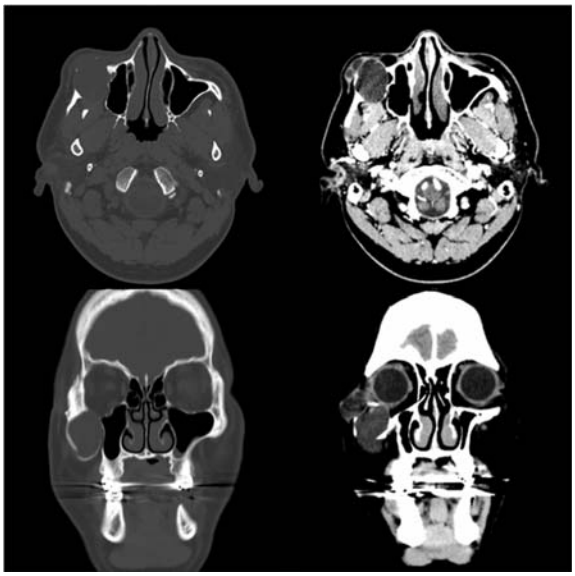

Figure 3. Pre-operative CT scan; Facial bone with contrast demonstrate a thin wall septate cystic lesion at the old fracture right zygoma with bony expansion, measure about 3.4x 3.3x3.6 cm and showing some intracystic hyperdense content. The lesion involves inferolateral wall of right orbit and attach to inferolateral aspect of right eye globe.

and fixed with screws to determine the resection margin. A reciprocating saw was used to excise the tumor, and the saw was controlled by the customized cutting guides. After removal of the tumor, the bony defect was reconstructed with the customized 3D titanium mesh plate and screw fixation. Finally, the wound was sutured layer by layer and the patient was extubated and sent to the recovery room in stable condition (Figure 5). The total operative time was 158 minutes, and the estimated blood loss was 60 ml. The patient was discharged home on postoperative day 5 in stable condition with no morbidity or complication. The final pathology report showed non-ossifying fibroma with secondary aneurysmal bone cyst, which was the same as the preoperative tissue biopsy finding, and all resection margins were free from tumor.

At the 1-month postsurgical follow-up, the patient expressed satisfaction with both the functional and aesthetic outcomes of surgery (Figure 6). Postoperative radiographic examination showed good bony contour and projection of the right infraorbital rim and zygoma. Symmetry of both zygomaticomaxillary complexes could also be observed (Figure 7).

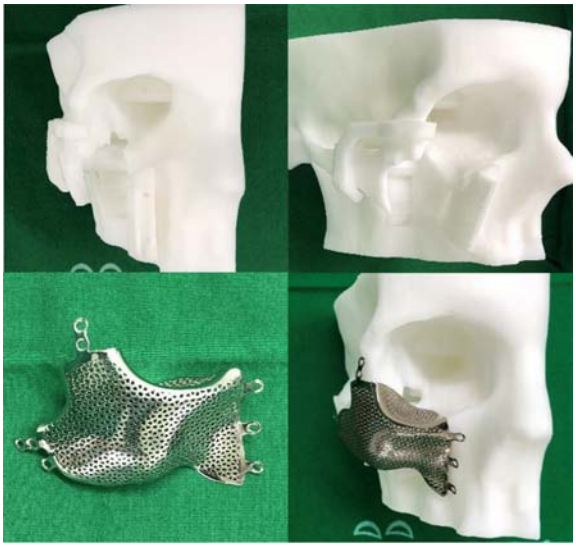

Figure 4. Pre-operative 3D model, Customized 3D cutting guides and Customized 3D titanium mesh plate were printed out and prepared for operation.

Figure 5. Intra-operative photo of the patient: A) Weber-Ferguson incision was used to approach the tumor. B&C) Customized 3D cutting guides were applied and fixed with screws, then reciprocate saw was used to excise tumor under control by cutting guides. D) Tumor size about 4.5x3.5 cm. E) The final defect after tumor extirpation include right maxilla, zygoma and orbital floor. F&G) Defect was reconstructed with customized 3D mesh plate and screws fixation. H) Immediate post-operative photo after wound closure.

Figure 6. Post-operative photo at 1 month after surgery. Surgical wounds were completely healed and no deficit both facial expression and masticatory function.

Figure 7. Post-operative radiographic examination shows a good bony contour and projection of right infraorbital rim and zygoma also symmetry of both zygomaticomaxillary complex.

Figure 8. Comparison of pre-operative photo (left) and post-operative photo (right) of the patient.

Discussion

CAD/CAM 3D virtual surgical technique is a promising technological advancement that can be applied in many surgical specialties, especially complex craniomaxillofacial reconstruction. This modality facilitates more reliable preoperative surgical planning, increases precision, reduces operative time, enhances postoperative functional and cosmetic outcomes, and increases patient satisfaction (Figure 8).

In this article, we report our experience with CAD/CAM 3D virtual surgical technique to successfully manage a large lesion at the right zygomaticomaxillary complex via tumor extirpation and defect reconstruction. This case will increase awareness of this surgical technology in Thailand, and its applicability may now be considered a treatment alternative in many surgical settings.

What is already known on this topic?

Nowadays, many institutes especial in the US and Europe already experienced with CAD/CAM 3D Virtual Surgery also tried to develop their own protocol and research by using this technology to improve the surgical outcomes. And for Thailand, Division of Plastic Surgery, Faculty of Medicine Siriraj Hospital is the first one and pioneer to use this technology for reconstructive purpose. And I certainly sure that this topic will be impact to all of reconstructive surgeon in our country to give their attention more about this new technology and try to adapt or change their surgical practice with this method to yield the better results.

What this study adds?

This will be the first report of our country (may be the first time in the world also) about the experience with CAD/CAM 3D Virtual Surgical technique especially for the patient that need maxillectomy and maxillary reconstruction. In this report we use technology of CAD/CAM 3D Virtual Surgery not only for pre-operative surgical planning but also create the customized cutting guide for maxillectomy and develop the customized titanium mesh plate for reconstructing maxillary defect after tumor extirpation.

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Potential conflict of interest

The authors declare no conflicts of interest.

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นวัตกรรมชุดเครื่องมือช่วยผ่าตัด Customized 3D Cutting Guide และ Customized 3D Titanium Mesh Plate สำหรับการผ่าตัดรอยโรคที่กระดูกกรามบน และผ่าตัดแก้ไข/เสริมสร้างกระดูกกรามบน

ณัฐวุฒิ อัครานุชาต, ณัชชา ยอดระบำ

ในบทความวิจัยนี้ คณะผู้นิพนธ์นำเสนอกรณีของผู้ป่วยชาย อายุ 39 ปี ที่มารับการตรวจรักษาด้วยอาการแสดงของก้อนโตเร็วที่แก้มด้านขวา ผลตรวจเพิ่มเติมทางรังสีวิทยาและพยาธิวิทยาเข้าได้กันกับโรค Non-ossifying fibroma with secondary aneurysmal bone cyst โดยก้อนกินกระดูกโหนกแก้ม (Zygoma) กระดูกกรามบน (Maxilla) และกระดูกฐานรองตา (Orbital floor) ด้านขวา

ผู้ป่วยได้รับการวางแผนผ่าตัดด้วยเทฆโนโลยีการผ่าตัดบนแบบจำลองฆอมพิวเตอร์ 3 มิติ (CAD/CAM 3D virtual surgery) และดำเนินการผ่าตัดภายใต้การกำหนดจุดตัดที่แม่นยำ ทั้งยังได้รับการผ่าตัดเสริมสร้างกระดูกโหนกแก้ม กระดูกกรามบน และกระดูกฐานรองตาขึ้นใหม่ ด้วยเทคโนโลยีการพิมพ์ 3 มิติ ซึ่งการผ่าตัดประสบความสำเร็จด้วยดี ให้ผลเป็นที่น่าพอใจทั้งในแง่ของการใช้งาน และความสวยงามของใบหน้า

นับเป็นก้าวที่สำคัญของสาขาศัลยศาสตร์ตกแต่ง ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล รวมถึงประเทศไทย กับการพัฒนางานด้านการผ่าตัดโดยการใช้เทคโนโลยีการผ่าตัดบนแบบจำลองคอมพิวเตอร์ 3 มิติ และด้วยการนำชุดเครื่องมือช่วยผ่าตัด 3 มิติ และไทเทเนียม mesh plate 3 มิติ ที่จำเพาะเจาะจงกับผู้ป่วยแต่ละรายมาใช้นั้น จะยิ่งช่วยให้เกิดการพัฒนาของงานในด้านการผ่าตัดแก้ไข/เสริมสร้าง ให้เป็นไปด้วยความถูกต้องแม่นยำ และตอบสนองต่อความต้องการที่จำเพาะของผู้ป่วยแต่ละรายได้ดียิ่งขึ้น