



# The use of computer-aided design and computer-aided manufacturing fabricated titanium prosthesis to restore maxillofacial defects: 4 cases report

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Computer-aided design and computer-aided manufacturing (CAD-CAM) techniques are leading to new and refined approaches to reconstructive surgery. While used mainly in craniofacial reconstruction so far, CAD-CAM technology has the potential for advances in every area of plastic and reconstructive surgery. Here we are reporting 4 different cases of maxillofacial defects reconstruction and the purpose of this report is to introduce a new methodology for contour restoration of the maxillofacial defects using CAD-CAM custom-made titanium prosthesis. With the help of CAD-CAM technology the rigid fixation of the custom-made titanium implants successfully restores the contour of maxillofacial defects in more symmetrical and aesthetic shape. However, without this technology restoring large defect is difficult as it requires strong prosthetic material like titanium use to restore the mandibular angle and border defects. We think that titanium prosthesis is an excellent choice for efficient and durable reconstruction of such large maxillofacial defects.

**Keywords:** computer-aided design; maxillofacial prosthesis; orthognathic surgical procedures; reconstructive surgical procedures; temporomandibular joint; titanium

## Introduction

Computer-aided design and computer-aided manufacturing (CAD-CAM) techniques are leading to new and refined approaches to reconstructive surgery. This emerging technology allows us to more closely replicate the actual patient providing access to more and higher-quality information thus improving the accuracy and reliability of diagnosis and treatment [1]. While used mainly in craniofacial reconstruction so far, CAD-CAM technology has the potential for advances in every area of plastic and reconstructive surgery. Recent advances in 3-di-

mensional (3D) imaging for maxillofacial surgery have enabled a huge evolution on this field and allowed unprecedented virtual diagnosis, treatment planning, and evaluation of treatment outcomes of maxillofacial deformities. The purpose of this cases report is to introduce a new methodology for contour restoration of the maxillofacial defects using CAD-CAM custom-made titanium prosthesis.

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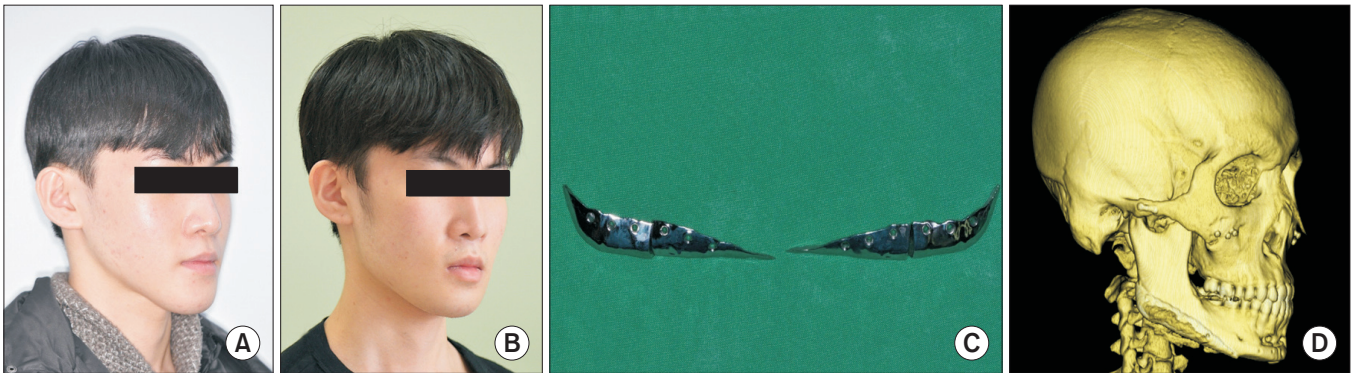
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## Case report

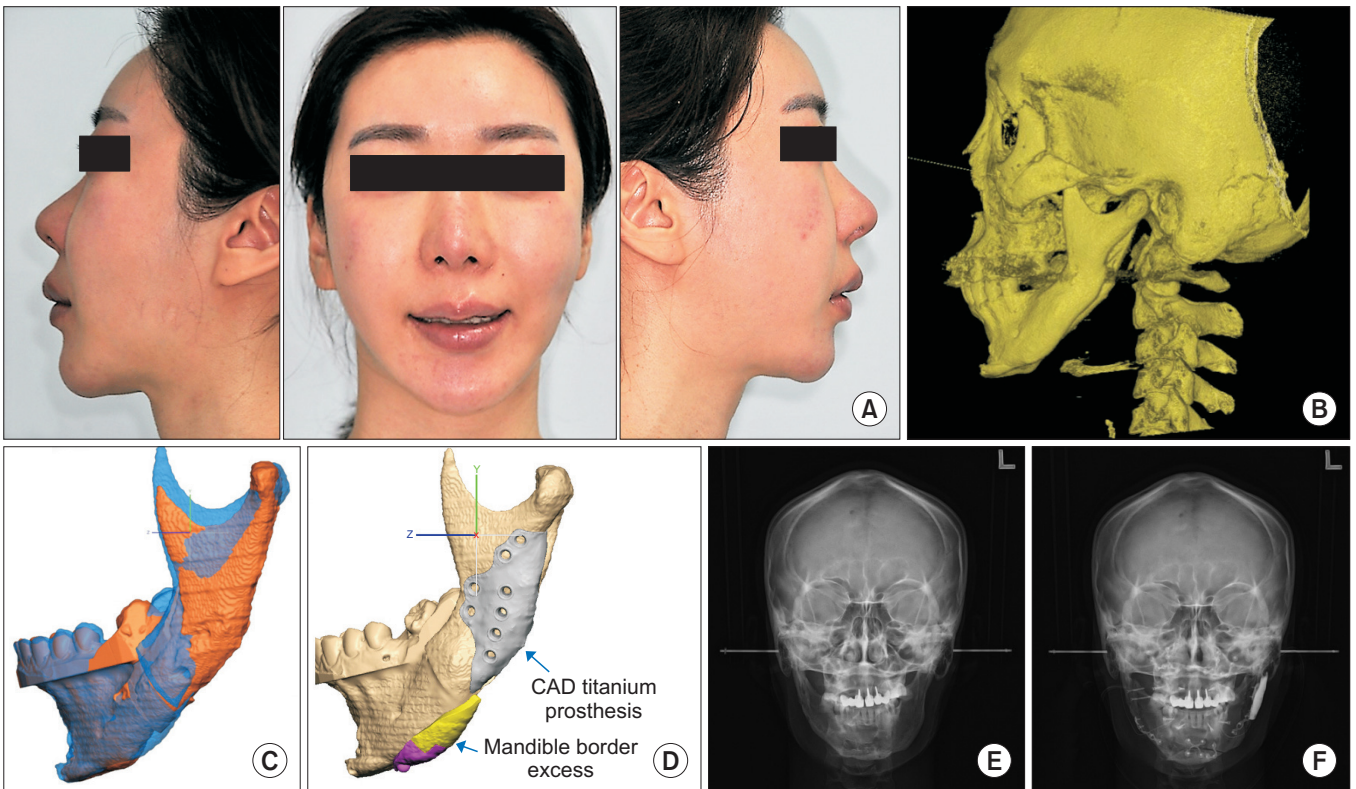
### Case 1

A 20-year-old Singapore male patient had undergone a reduction of the zygomas, mandibular angles, and lower borders on both sides for esthetic reason 1 year ago at a private clinic. However, he was not satisfied with the surgical outcome (Fig.

1A) and wanted to restore his original facial volume and contour. To assess the volume and dimension of resected bone, 3D-computed tomography (3D-CT) data at the original stage was superimposed with postsurgical CT. For the restoration of the malar prominence, porous polyethylene malar implants with extensions into the lateral malar region (Medpor; Stryker, Kalamazoo, MI, USA) were placed and fixed with mini screws.



**Fig. 1.** Preoperative (A) and postoperative (B) clinical photographs. (C) Mandibular angle and border contouring custom-made titanium prosthesis. (D) Right lateral view of postoperative 3-dimensional computed tomography.



**Fig. 2.** (A) Preoperative clinical photographs. (B) Left lateral view of 3-dimensional computed tomography showing defected ramus. (C) 3D superimposition for asymmetry detection. (D) 3D virtual image of mandible showing the excess in left mandible inferior border and designed titanium prosthesis for defected ramus. (E) Preoperative posteroanterior (PA) radiograph. (F) Postoperative PA radiograph. CAD, computer-aided design.

Custom-made titanium implants were fabricated for contour restoration of the mandibular angle and lower border using CAD-CAM technology (iDDA, Daegu, Korea). Two-piece design per each titanium implant was adopted for easy placement and avoidance of mental nerve damage during placement (Fig. 1C). The thin buccal extension was incorporated for placement of screw holes. Location, direction, and length of bicortical screws were planned to avoid damage of the inferior alveolar nerve. Finally, with the help of 3D planning and CAD-CAM technology, rigid fixation of the custom-made titanium implants into the mandibular angle and lower border successfully restored the contour of the over-resected mandible to the original state (Fig. 1B, D).

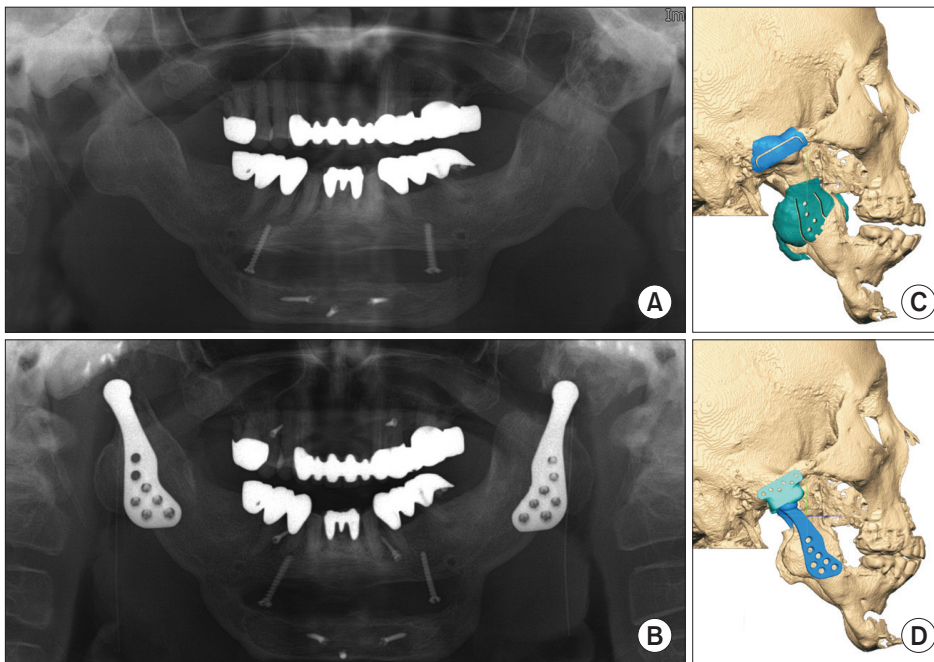
### Case 2

A 30-year-old Korean female patient had undergone orthognathic surgery 8 years ago at a local clinic. As we understand from her history, it seems that she got left subcondylar fracture as a complication of the previous surgery and this led to mandibular defect and facial asymmetry due to malunion of two fractured segments. That is why she presented to our Department of Oral and Maxillofacial Surgery at Seoul National University Dental Hospital complaining from facial asymmetry (Fig. 2A, E). Upon clinical examination and radiographic analysis, we found that her mandible deviated to the left side and the maxilla was canted down on the right side. Using 3D-CT superimposition a ramus deficiency and mandibular body border

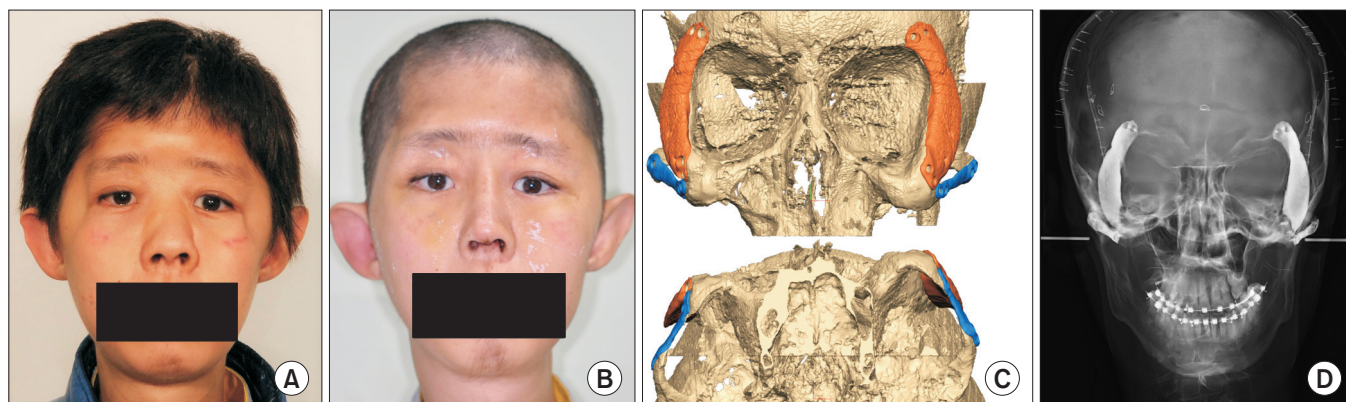
excess were detected in the left side of her mandible (Fig. 2C). Then CAD-CAM titanium reconstruction prosthesis and border excess cutting guide (surgical stent) were prepared (Fig. 2D). For correction of facial asymmetry, re-operation orthognathic surgery was done for her and in conjunction with that left mandibular excess resection using the surgical stent and contouring of defected mandibular ramus with custom-made titanium prosthesis is successfully placed and fixed resulting in a nice symmetrical mandibular ramus (Fig. 2F).

### Case 3

A 66-year-old Korean female presented to our Department of Oral and Maxillofacial Surgery at Seoul National University Dental Hospital with a chief complaint of limited mouth opening (maximum mouth opening was 8 mm). Upon clinical examination and radiographic analysis, she was diagnosed with completely ankylosed bilateral (temporomandibular joints, TMJs) (Fig. 3A). In her case, we used ready-made artificial TMJs (Zimmer Biomet, Warsaw, IN, USA) and by the aid of CAD-CAM (FACEGIDE; MegaGEN IMPLANT Co., Ltd., Daegu, Korea) we made custom-made surgical stent. Through bilateral pre-auricular incisions, both ankylosed TMJs' condylectomies were done and replaced with the artificial TMJs. The surgical stent was used to guide us to know the exact location of ankylosed TMJ resection and new TMJ fixation (Fig. 3C). This simplified the surgical procedure and resulted in accurate positioning and fixation of fossa and condylar part. Post-operatively she



**Fig. 3.** (A) Preoperative panoramic view. (B) Postoperative panoramic view. (C) Three-dimensional (3D) design of surgical stent. (D) 3D design of artificial temporomandibular joint in the planned position.



**Fig. 4.** Preoperative (A) and postoperative (B) clinical photographs. (C) Frontal view and inferior view of 3D design of lateral walls and zygomatic arches. (D) Postoperative posteroanterior radiograph.

ends up by functioning TMJs with 30 mm mouth opening.

#### Case 4

A 31-year-old Korean male patient presented to our Department of Oral and Maxillofacial Surgery at Seoul National University Dental Hospital and wanted to fill up depressed both lateral orbital wall nasal dorsal depression. He is a Crouzon syndrome patient and underwent a Le Fort III osteotomy and rigid external distractor insertion via coronal approach 1 year ago. On clinical examination and further investigations, we found that bilaterally deficient lateral orbital walls and zygomatic arches existed (Fig. 4A). As understood from reviewing the history, the midface osteogenesis distraction improved the maxilla but deficient osteogenesis occurred in the lateral orbital walls and zygomatic arches which result in this deformity. To overcome the deformity and fill up the deficiencies, bilaterally lateral orbital walls and zygomatic arches contoured with CAD-CAM titanium prosthesis (Fig. 4C). Also, dorsum augmentation rhinoplasty was done simultaneously. By looking to the patient in postoperative and compare his image to the preoperative image, we can easily find that the deficiencies were perfectly contoured (Fig. 4A, B).

#### Discussion

The modern 3D virtual planning has critical advantages compared to conventional treatment planning as conventional model surgery in orthognathic surgery require many laboratory-based steps that are time-consuming and may lead to potential errors [2]. Furthermore, reference lines in the models are drawn by hand using a ruler or caliper on plaster casts that do not represent the patient's bone structure or the osteotomy

lines that will be used in surgery. As 3D planning, CAD-CAM custom-made splints and prosthesis are used this can improve the accuracy and reliability of diagnosis and treatment. The accuracy of the rapid prototyping procedures for orthognathic surgery is now beyond all questions and the reliability of these CAD-CAM generated splints has already been validated [3]. However, even with CAD-CAM, the prediction of outcomes is very difficult because the overlying soft tissues are still not reliably represented. Also, a static representation of the patient's tissues at the point of image capture. Hence, a detailed physical examination is still absolutely essential in order to obtain extremely valuable dynamic information for precise surgery planning [4].

What we want to say that, with the help of CAD-CAM technology the rigid fixation of the custom-made titanium implants successfully restores the contour of maxillofacial defects in more symmetrical and aesthetic shape. However, without this technology restoring large defect, as in the 1st case of this report, is difficult as it requires strong prosthetic material like titanium use to restore the mandibular angle and border defects (Fig. 1). Also, emerging technology as this helps to achieve a precise diagnosis and made almost perfectly designed prosthesis and we have an example of accurate defect amount detection in the mandibular ramus of the 2nd case, amount of mandibular border excess ground with a guide of designed surgical stent and symmetrically precise restoration of the deficient ramus (Fig. 2). In addition to that, the 3rd case can show us that intraoperative consumed time is decreased by using customized surgical stents to locate and fix fossa and condyle accurately (Fig. 3). We think that titanium prosthesis is an excellent choice for efficient and durable reconstruction of such large maxillofacial defects. Moreover, without the aid of CAD-CAM, it is impossible to eas-

ily and perfectly reconstruct some of the maxillofacial defects as it is clearly seen in lateral orbital walls and zygomatic arches deficiency reconstruction in the 4th case (Fig. 4).

## Conclusion

Preoperative virtual planning and the transfer of these plans to the operation theater can aid to increase surgical precision, improve rehabilitation and decrease postoperative morbidity and operation time. However, Postoperative predictions still lack some reliability and further study with larger sample size is necessary to confirm the results obtained in this report.

## Conflicts of interest

The authors have nothing to disclose.

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