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Technical procedure

Computer assisted mandibular reconstruction using a custom-made titan mesh tray and removable denture based on the top-down treatment technique

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ABSTRACT

Purpose: The purpose of this report is to propose a computer assisted mandibular reconstruction procedure, utilizing a custom-made Ti-mesh tray with particulate cancellous bone and marrow, and a removable denture. This procedure was based on the top-down treatment technique, and reviews the case of a representative patient with mandibular continuity defect.

Methods: The patient was a 74-year old female with a chief complaint of facial asymmetry and masticatory dysfunction. Due to gingival carcinoma, she underwent a segmental mandibulectomy on the left mandible.

On the VR space, using 3-D reconstructed computer tomography data, the residual right-side mandibular fragment was repositioned based on the condylar position and the occlusal relation. The mandibular fragment was then mirrored for a central sagittal plane. The position of the mirrored object was slightly arranged with the occlusal relation. Through the above operations, the landmark configuration, for the custom-made Ti-mesh tray as a virtual simulation model, was fabricated. On the physical model, we produced a custom-made Ti-mesh tray with a commercial Ti-mesh sheet. Surgical treatment was carried out using the tray.

The denture pattern was designed by a dental technician on the VR space, fabricated using a 3D printer, and modified to create an impression tray with resin. Using the impression, the temporary removable denture was fabricated.

Conclusions: We propose a computer assisted design for a custom-made Ti-mesh tray and a removable denture, based on the Top-down treatment concept. We feel this technique is

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advantageous in reconstructing functional occlusion, and in accurately regaining dental and facial esthetics.

1. Introduction

Mandibular discontinuity, caused by tumor ablation or trauma, has normally been reconstructed by using vascularized or non-vascularized block bones. However, block bones cannot reproduce the natural curve and configuration of the defected mandible. In the 1990s, several oral and maxillofacial surgeons attempted to produce a more accurate mandibular reconstruction with a custom-made Titanium (Ti-) mesh tray and particulate cancellous bone and marrow (PCBM) [1,2]. A commercially available Ti-mesh tray, called the "Dumbach Titan Mesh-System" (DTM) (Stryker-Leibinger, Freiburg, Germany), was also introduced [3]. Since then, mandibular reconstruction, using DTMs and PCBM, have been applied to a wide range of mandibular discontinuity, and with reports on their clinical advantages being reported [4,5]. Nevertheless, DTMs had limitations in reproducing the configurations of defective mandibles and fitting to the residual mandible, due to the three-dimensional (3-D) prefabricated configuration of the DTMs by the manufacturer [4]. These limitations may disturb the top-down prosthodontic treatments after mandibular reconstruction. Unfortunately, DTMs have disappeared from market.

On the other hand, the physical models fabricated by computer-assisted design (CAD), computer-assisted manufacturing (CAM), and rapid prototyping (RP) technologies have contributed to more accurate mandibular reconstruction. In fact, they have been used for surgical simulation of mandibular reconstruction, and pre-processing or pre-fabrication of reconstruction materials [6–8].

With the aforementioned background in mind, we attempted to fabricate a commercial Ti-mesh sheet into a custom-made Ti-mesh tray. To achieve this, we used 3-D reconstructed data from computer tomography data, and fabricated a physical model. From this model, we transformed a commercial Ti-mesh sheet into a custom-made Ti-mesh tray, reproducing an accurate configuration of the defective mandible. This physical model was based on the X-ray computer tomography (CT) 3-D data. This report reveals a computer assisted mandibular reconstruction procedure, utilizing a custom-made Ti-mesh tray with particulate cancellous bone and marrow, and a removable denture. This procedure was based on the top-down treatment technique, and reviews the case of a representative patient with mandibular continuity defect.

2. Materials and methods

2.1. Subject

The patient was a 74-year old female with a chief complaint of facial asymmetry and masticatory dysfunction. Due to gingival carcinoma, she underwent a segmental mandibulectomy on the left mandibule in May of 2008.

Due to a mandibular deviation to the left side, she had a malocclusion and facial asymmetry (Figs. 1 and 2). The extent of the mandibular deviation was observed in the terminal position of her habitual closing movement (Fig. 3). A 3-dimensional (3-D) computed tomography (CT) revealed a mandibular continuity defect from #33 to the base of the left condylar process, which anteriorly dislocated out of the fossa (Fig. 4).

To re-establish her precise occlusion and facial symmetry, computer assisted reconstructive surgery and prosthodontic treatments, based on the top-down treatment, were required. We planned for a surgical mandibular reconstruction using a custom-made Ti-mesh tray and autogenous particulate cancerous bone and marrow (PCBM). After that, a removable denture would be set on the reconstructed mandible.

Our treatment plan of attempting a mandibular reconstruction, incorporating a custom-processed Ti-mesh tray, was reviewed and approved by the Ethics Committee at Tsurumi University (Approval number:915). Informed consent was obtained from all patients who underwent the treatment mentioned in the documents.

The following sections demonstrate each step of the treatment procedures.

2.2. Methods

2.2.1. Fabricating the reconstructed 3D model

CT data was taken from the patient. The CT apparatus in our hospital (Tsurumi University Dental Hospital) is a Radix Prima (Hitachi Medical Co. Ltd., Tokyo, Japan). The parameters used for the imaging are tube voltage = 120 kV; tube current = 75 mA; irradiation time = 1 s; scan = volume scan; slice thickness = 1 mm; table speed = 1 mm/s. The CT data has a scanning matrix size of 256 × 256 pixels.

CT data was segmented semi-automatically based on Hounsfield units. Afterwards, the skull model was reconstructed with the CT data. These procedures were performed via image analysis software, Amira 4.1 (Mercury Computer Systems/3D Viz. group, San Diego, CA, USA). However, in this step, the dentitions in the virtual skull models of most patients contain artifacts caused by metal dental prostheses. Therefore, we had to obtain a more precise rendering of dentition to replace the data of the dento-alveolar region on the CT data. Thus, a dentition model was reconstructed from 3D laser surface scanning data from a 3D scanner (Tsurumi Univ. prototype) and 3D mesh modeling software VRMesh 4.1 (Virtual Grid, Seattle City, WA, USA). A fusion model combines data from both the skull model and the dentition model by Iterative Closest Point (ICP) algorithm and was reconstructed via VRMesh 4.1.