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Original Article

A fixation guide for the accurate insertion of fibular segments in mandibular reconstruction

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ABSTRACT

Background: Computer-aided design and computer-assisted manufacturing (CAD/CAM) of cutting guides are now being used in mandibular reconstruction with fibular bone flaps. Improvements in guide design and accuracy are needed to increase the benefits to patients. Cutting guides have become popular, but fixation guides are rarely considered.
Materials and methods: The aim of this study was to determine whether using a fixation guide would contribute to better accuracy in mandibular reconstruction. Mandibular segmental osteotomies and fibular reconstructions were performed using model surgery. Models were divided into two groups: without or with a fixation guide ($n = 13$ for each group). After reconstruction, the distances between reference points such as the condylion laterale (Cl), gonion, and mental tubercle (T) were measured and compared with those of the preoperative virtual plan. Deviations in final positions between the two groups were analyzed.
Results: The mean deviations were 2.61 mm (range 0.05–7.65 mm) and 2.05 mm (range 0.07–8.52 mm) in the groups without and with a fixation guide, respectively. The overall results were significantly better when a fixation guide was used ($p = 0.03$). Distances including the Cl reference points such as Cl–Cl ($p = 0.02$) and Cl–T ($p = 0.001$) were particularly improved.
Conclusions: Using a fixation guide together with a cutting guide makes mandibular reconstruction more accurate, particularly for

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positioning the Cl reference points. Therefore, when a CAD/CAM-produced cutting guide is used in preparation for surgery, it is recommended to use a fixation guide as well for more accuracy.

Introduction

Computer-aided design and computer-assisted manufacturing (CAD/CAM) are frequently applied in the fields of oral and maxillofacial surgery. After resection of malignant tumors, mandibular reconstruction using a free fibular flap and a CAD/CAM-generated cutting guide is considered to be more accurate than conventional reconstruction.[1–6] Moreover, this technique is expected to contribute to shorter surgical times and overall cost savings.[7]

As CAD/CAM-generated surgical guides are not yet commercially available in our country because of import regulations, we have been using our own surgical guides, aiming for more accurate reconstruction. However, we noticed that in some cases, especially those in which the transferred fibular bone needs to be split into several segments, deviation errors after reconstruction are not minimized as much as expected. Of course, these deviations are smaller than those with conventional methods; however, the smaller the deviation, the better the result will be. Therefore, we designed a new fixation guide, aiming to make the split bone placements as accurate as planned in real-time surgery. The purpose of this study was to judge whether this new fixation guide would contribute more accuracy to the placement of autologous bone grafts than surgery performed without using fixation guides.

Materials and methods

Because commercial CAD/CAM guides are not available in our country, we planned mandibular segmental osteotomies and fibular reconstructions virtually using free CAD software. Briefly, to produce three-dimensional (3D) STereoLithography (STL) files of the mandible and the fibula, DICOM data were imported into the free public software InVesalius (Information Technology Center, Renato Archer Center of the Ministry of Science and Technology, Campinas, Brazil). These STL files were imported to the free CAD software Blender (The Blender Foundation, Amsterdam, The Netherlands). For preparing the models, we used a 3D printer (MakerBot Industries, Replicator 5th, New York City, NY, USA). Model surgeries and measurements of the reference points were performed for 13 pairs of human mandibles and fibulas with the anonymous donors' consent. Defective areas were set randomly (Figure 1), but the condylion laterale (Cl) site was not chosen for this. To improve the ease of making measurements, reference points such as the Cl, gonion (Go), mental tubercle (T), menton (Me), and pogonion (Pog) were set in the virtual mandibles.

We planned two experimental groups. In one group ($n = 13$), the mandibular segmental osteotomies and fibular reconstructions were performed using a conventional CAD/CAM-designed cutting guide. In the other group ($n = 13$), in addition to the cutting guide, a fixation guide was used for placing the fibular bone segments into the mandibular defects. Mandibles, fibulas, and defects were the same in both groups because we used the same 13 pairs of STL data. After reconstruction, the accuracies of placing reference points were compared between the groups.

Virtual plan of osteotomies and fibula transfer (Figure 2)

Segmental osteotomy was performed virtually. The defects were replaced using fibular bone transfers. The Go and T points were reproduced. To achieve these osteotomies and transplants virtually, a cutting guide was designed, which also had a role as an external fixator of the remaining portion of the mandible. A fibula-cutting guide was also planned.