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Evaluation of the anterior mandibular donor site one year after secondary reconstruction of an alveolar cleft: 3-dimensional analysis using cone-beam computed tomography

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Abstract

The aim of this study was to analyse changes in the volume of the chin after harvest of a bone graft for secondary reconstruction of an alveolar cleft. Cone-beam computed tomographic (CT) scans of 27 patients taken preoperatively, and immediately and one year postoperatively, were analysed, and 3-dimensional hard-tissue reconstructions made. The hard-tissue segmentation of the scan taken one year postoperatively was subtracted from the segmentation of the preoperative scan to calculate the alteration in the volume of bone at the donor site (chin). A centrally-orientated persistent concavity at the buccal side of the chin was found (mean (range) 160 (0-500) mm^3). At the lingual side of the chin, a central concavity remained (mean (range) volume 20 (0-80) mm^3). Remarkably, at the periphery of this concavity there was overgrowth of new bone (mean (range) volume 350 (0-1600) mm^3). Re-attachment of the muscles of the tongue resulted in a significantly larger central lingual defect one year postoperatively ($p = 0.01$). We also measured minor alterations in volume of the chin at one year. Whether these alterations influence facial appearance and long term bony quality is to be the subject of further research.

Keywords: Secondary alveolar reconstruction; Bone graft; Cleft lip and palate; CBCT; Three-dimensional

Introduction

Alveolar reconstruction of bony defects in patients with cleft lip and palate is a widely accepted treatment to provide necessary continuity to the maxilla. Multiple donor sites, such as the rib, the chin, and the iliac crest, can be used to harvest the required bone graft.[1]

Previous conventional radiographic studies have assumed that the donor site on the chin almost completely regenerates by one year postoperatively.[2–4] However, these studies used 2-dimensional imaging techniques to assess a 3-dimensional anatomical structure, so the conclusion may be debatable.

Cone-beam computed tomography (CT), a new and accurate technique, has now become available to visualise the effects of treatment over time with minimal exposure to radiation.[5,6]

The aim of this study was to analyse the healing process of the donor site on the chin 3-dimensionally one year after a bicortical graft had been harvested for the reconstruction of an alveolar cleft. An additional goal was to assess whether

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independent variables associated with the surgical technique or patient-specific factors had any influence on regeneration.

Patients and Methods

The study was approved by the Medical Ethics Commission of the Radboud University Medical Centre.

Medical records of patients who were operated on for early secondary reconstruction of the alveolar process using a bone graft from the chin between September 2007 and April 2012, were reviewed and cone-beam CT scans taken preoperatively (less than one year), immediately postoperatively (less than two weeks), and one year (more than nine months) postoperatively, were abstracted. Exclusion criteria were no scan or a scan of insufficient quality because of artefacts.

Additional variables such as sex, age, the use of bone wax at the donor site, and reattachment of the tongue muscles during operation, were extracted from the patients' files, and tested as possible predictor variables. Use of alkylene oxide copolymers such as Ostene® (Baxter Healthcare Coorperation, Deerfield, IL, USA) was disregarded because, unlike insoluble bone wax, it does not inhibit bony healing.[7]

Operative technique

The same surgeon (WB) did all the operations, which were planned after eruption of the maxillary lateral incisors, and before the eruption of the canine on the cleft side.[3,8] The protocol has previously been described in detail.[9] After local anaesthetic had been injected into the vestibule of the mandible, a marginal incision was made into the gingival sulcus, the mucoperiosteum was deflected, and the chin exposed. To prevent apical damage, we kept a 5 mm safety margin around the apices of the lower incisors. A bicortical bone transplant was created with an oscillating saw, which preserved at least 5 mm of the lower mandibular border (Fig. 1). After dissection the bicortical symphyseal bone graft was raised from the lingually attached muscles (musculus genioglossus and musculus hyoglossus). Small holes were created in the lower mandibular border, through which the muscles were reattached with sutures.

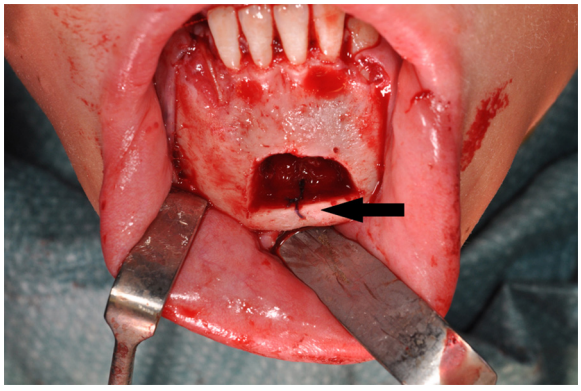

Fig. 1. Perioperative ventral view of the chin after a bicortical chin bone graft has been harvested and the muscles reattached (black arrow).

Processing of images

Cone-beam CT scans were acquired with the i-CAT® 3D Imaging System (Imaging Sciences International Inc, Hatfield, PA, USA). Patients were scanned while seated with the head in the natural position using a standard protocol (field of view 13 cm diameter; scan time 20 seconds; voxel size 0.4 mm) at 120 kV and 3-8 mA pulse mode. The imaged data were exported in DICOM format and successively imported into the image processing software (Maxilim version 2.3.0, Medicim N.V., Mechelen, Belgium).

Three-dimensional models were reconstructed from the preoperative, immediately postoperative, and one-year postoperative scans. Because the mandible was the region of interest for this study, the image volumes were superimposed using voxel-based matching on to the anterior mandibular region using the method described by Maes et al.[10] and Nada et al.[5]

Measurements of the surface of the bone

The method used to calculate the area of the cortical defect immediately postoperatively is shown in Fig. 2. Cortical bone was segmented using an isovalue threshold of 900 in both the preoperative and immediately postoperative scans. Subtraction of the immediately postoperative segmentation from the preoperative segmentation generated an image label showing bicortical areas (Fig. 2). The surface areas of both the buccal and lingual defects were calculated perpendicular to an orientation vector that connected their respective centres of gravity.

To evaluate the volume of the defect one year postoperatively, the anterior mandibular region was segmented in the preoperative and one-year postoperative images. The mandible was segmented automatically using a standard threshold specified in the Maxilim software for the i-Cat® scanner, after which each segment was evaluated and corrected, if necessary, using manual relabelling. Correction was based on visual assessment of cortical boundaries and alterations in isovalues between scans. The amount of bone lost was calculated by the subtraction of the segmentation label one year postoperatively from the preoperative label (Fig. 3). Bony overgrowth was visualised by the subtraction of the preoperative segmentation from that made one year postoperatively. W also evaluated the inter-observer reliability of this segmentation protocol.

Statistical methods

We used the Mann-Whitney *U* test was used to find out whether the patient's sex, reattachment of the tongue muscles, and use of bone wax were related to volumetric changes one year postoperatively. We also calculated Spearman's rank