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Risk factor analysis of bone resorption following secondary alveolar bone grafting using three-dimensional computed tomography

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KEYWORDS
Alveolar bone grafting;
Bone transplantation;
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Summary *Background/Aim:* The purpose of this study is to analyze the risk factors for bone resorption following secondary bone grafting in the alveolar cleft, using three-dimensional (3D) computed tomography (CT) based on surgical simulation software (SimPlant OMS, Materialise Dental, Leuven, Belgium).
Methods: We reviewed the secondary alveolar bone grafts performed by a single surgeon between January 2005 and January 2014. A total of 40 patients with unilateral alveolar cleft were included in this study. The grafted alveolar bone was measured using surgical simulation software. In order to validate the measurement, each data set was measured by three different analysts and the inter- and intraobserver variabilities were calculated. A total of eight risk factors for grafted bone survival, including patient age, sex, body mass index (BMI), palatal fistula, amount of grafted bone, dental appliance, canine or incisor eruption, and preoperative upper respiratory tract infection, were evaluated using the linear mixed model and Mann—Whitney test.
Results: The average alveolar defect size was 4.98 cc and the average graft survival was 67.5%. The inter- and intraobserver variabilities of simulation software were 0.758 and 0.915, respectively. Among the risk factors, only dental appliance ($p = 0.02$) and canine eruption ($p = 0.041$) were significantly correlated with graft survival. Other risk factors, including the amount of grafted bone, did not show a significant relationship with graft survival.
Conclusion: Measurement of an alveolar bone defect using a simulation program based on 3D CT is reliable and reproducible. Secondary bone grafting survival was significantly correlated

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with canine eruption and dental appliance in the alveolar cleft.

Introduction

Radiographic imaging is frequently used for the diagnostic evaluation and treatment planning of patients requiring alveolar bone grafts. However, conventional radiographic imaging, such as occlusal or dental periapical radiographs, have the disadvantage of attempting to derive three-dimensional (3D) information from a two-dimensional (2D) image.[1,2]

Over the past few decades, computed tomography (CT) has been receiving increasing attention because of its precision and accuracy in locating anatomical structures and pathologic processes and visualizing maxillary and mandibular abnormalities.[3] It has recently been identified as a useful clinical tool in the assessment of diagnosis and treatment of alveolar bone grafting.[4,5] Although axial CT scans provide much information, they emit a considerably higher dose of radiation to young patients. Therefore, cone beam CT has been proposed and used as an alternative, because of its low cost and lower radiation exposure.[6,7] Cone beam CT calculation of a simulated alveolar cleft and bone graft volume is also precise and accurate.[6] Zhang et al. reported that 3D reconstruction based on cone beam CT is a promising method for evaluating the outcome of alveolar bone grafts and that bone grafts showed a high grade of resorption in patients lacking permanent tooth eruption.[8]

Several factors contribute to the success of secondary alveolar bone grafting. Sandy et al. reported that the younger the patient, the higher the rate of graft survival.[9] Several studies have demonstrated that the success rate of bone grafts decreases if the procedure is performed after canine eruption on the cleft side.[9–14] Shuji et al. reported that the optimal time for surgery is when the canine cusp is close to the alveolar plane.[14] Sex of the patient, type of cleft, and severity of the alveolar bone defect did not affect the success rate of secondary alveolar bone grafting.[9,15] However, there have been only few studies on the risk factors for secondary alveolar bone graft survival, which have no consensus.

To the best of our knowledge, this is the first study of its kind that analyzes the risk factors for bone resorption following secondary alveolar bone grafting using 3D reconstruction based on cone beam CT.

Method

A total of 40 secondary alveolar bone grafting cases were retrospectively reviewed between January 2005 and January 2014. The mean patient age was 9.15 years (range 6.7–12.8 years), and there were 16 female and 24 male patients. The inclusion criteria were unrepaired unilateral cleft, no previous history of alveolar bone grafting, and nonsyndromic children. Autogenous particulate cancellous bone was harvested from the anterior iliac crest with a minimal incision.

Data acquisition

Cone beam CT (3D Accuitomo 170; J Morita, Kyoto, Japan) scans were taken preoperatively and 1 year postoperatively. The exposure factors were 80 kV, 2 mA, and 17.5 s. Scans were taken from the occlusal plane to the nasal cavity to minimize radiation exposure to radiosensitive structures such as the thyroid gland and eye lens. The slice thickness was 1 mm and the field of view was 60 mm in height and 60 mm in diameter. In order to perform volume rendering, all data sets with the DICOM (Digital Imaging and Communications in Medicine) format were transferred to surgical simulation software (SimPlant OMS, Materialise Dental, Leuven, Belgium).

We anatomically confined the alveolar defect as above the pyriform aperture, below the cervical line, where the cementum meets enamel, and lateral to the maxillary bone defect. Grafted bone survival was calculated as follows: successfully grafted bone estimated using cone beam CT and surgical simulation software/cancellous iliac bone measured using syringe X 100 = graft survival % (Figure 4).

In order to validate the volume measurement using simulation software, preoperative cleft defect volume measurements were performed thrice by three independent analysts (nine times in total). During the secondary alveolar bone grafting, the grafted bone volume was estimated using a syringe (Figure 4).

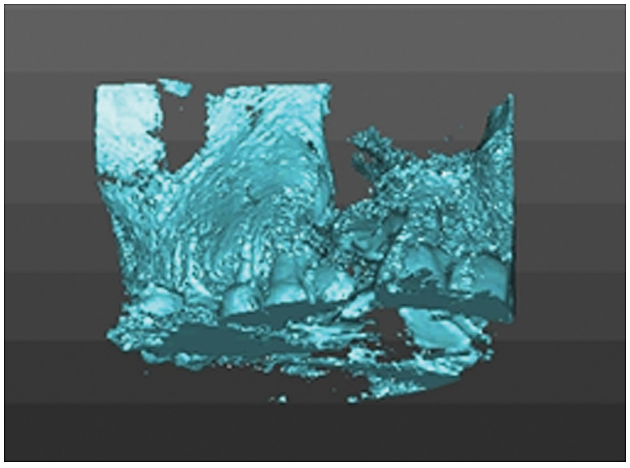

Figure 1 3D reconstruction image of an alveolar bone defect produced using SimPlant OMS software.