The Application of Cone Beam CT Image Analysis for the Mandibular Ramus Bone Harvesting

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Ⅰ. Introduction

Cortical bone grafts harvested from the posterior mandible offer several advantages for bone augmentation prior to implant placement. These grafts maintain their dense quality and exhibit minimal resorption upon incorporation. Considerable amounts of bone can be harvested from this area for use as an onlay graft. In addition, the ramus area has some inherent advantages over other donor sites[1]. But harvesting bone from the ramus requires knowledge of the mandibular canal anatomy to prevent nerve injury. And the main limitation of intraoral bone grafts is the limited supply of autogenous bone. The most common treatment planning error is to overestimate the available bone for harvest from the manidble[2]. The goal of this study was to quantify the amount of bone graft material present in the anterior part of ascending ramus or the posterior retromolar area while avoiding the inferior alveolar neurovascular bundle injury by 3-dimensional image analysis provided CBCT(cone beam computed tomography).

Ⅱ. Materials & Methods

Two cases required the mandibular ramus bone harvesting before the placement of implant were presented in this study. One case harvested bone from the retromolar pad area with the trephine bur, the other from the ascending ramus of the mandible with the surgical bur. CT images produced by i-CATTM (ISI, USA) system (Fig 1.) and reformatted using Simplant TM (Materialise, Belgium) software tool(Fig 2.). The amount of required bone material was estimated in each cases and the bone volume which can be harvested also simulated by software before surgery. From the measurement of the surgical defect on the post operative CT image, the amount of harvested bone volume could be calculated.

Fig 1. Cone Beam Computed Tomography System (i-CAT™, ISI, USA)

Fig 2. Simplant™, Materialise, Belgium software tool

· Case 1

In the preoperative reformatted CBCT images, floating tooth appearance noted on left mandibular first molar area with severe resorption of alveolar bony height. In the simulation of implant placement on this site, the bony height was insufficient for 10 mm length implant fixture and bone graft must be required(Fig 3.). The amounts of required graft bone material was estimated about 0.4 cc (Fig 4.).

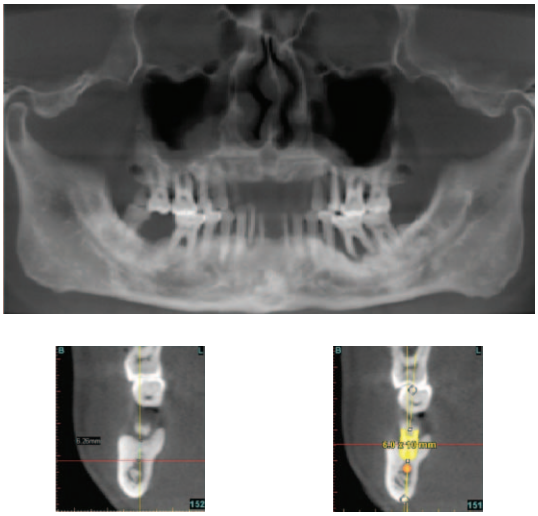
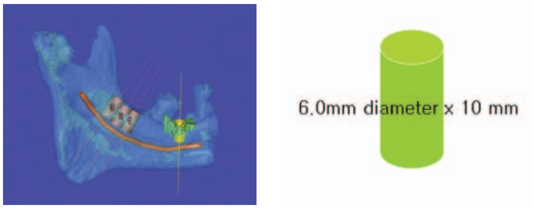


Fig 3. Preoperative CBCT images

Fig 4. Simulation of bone graft

The mandibular ramus on left side was decided as bone harvesting site by a 6 mm diameter trephine bur. In the 3-dimensional reformatted image three cylinders (6 mm diameter, 10 mm height) were overlapped in the virtual space and cylinders represented the placement of trephine bur during bone harvesting. The spatial relationship between cylinders and inferior alveolar canal was evaluated on serial crosssectional views. From the simulation procedure we expected the amounts of bone material which can be harvested as about 0.6 cc (Fig. 5.).



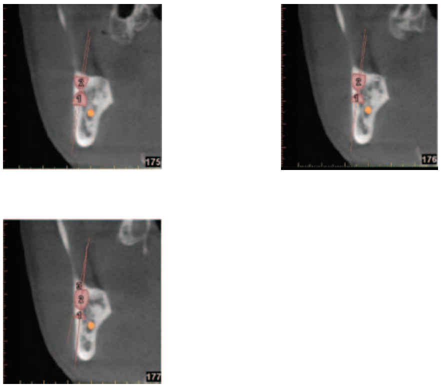


Fig 5. Superimposition of three cylinder represent trephine bur

During surgical procedure, bone harvested on the left mandibular retromolar pad area and four bone core collected by trephine bur (Fig 6.). Using the postoperative CBCT images, the amounts of harvested bone could be measured on the surgical defect area. In this case the volume of surgical defect was measured about 0.8 cc. The distance between surgical defect with inferior alveolar canal revealed above 2.0 mm on serial crosssectional views (Fig 7.)

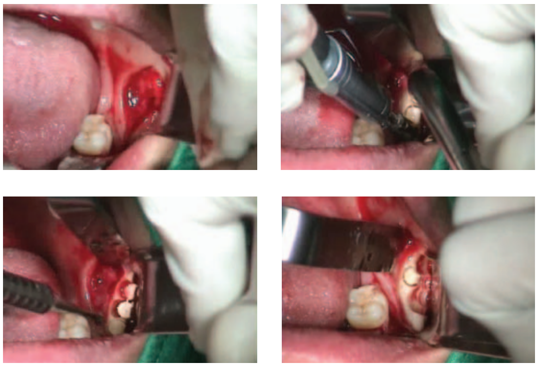


Fig 6. Surgical Procedure

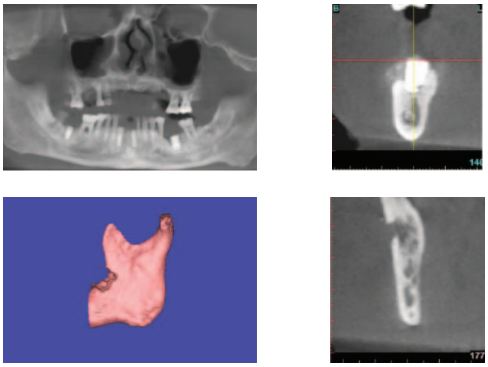


Fig 7. Postoperative CBCT image analysis

· Case 2

In the second case, the patient planned implantation on the left maxillary first molar area. The remaining bone height was measured 1.7 mm and it was insufficient

for 13 mm implant. And then sinus graft procedure was chosen for implant placement (Fig 8.).

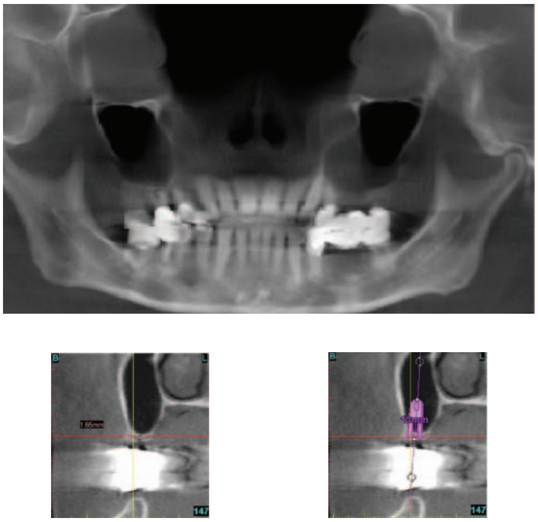


Fig 8. Preoperative CBCT images

Using the preoperative CBCT images, the simulation of sinus graft for 13 mm implant fixture was conducted on crosssectional and 3-dimensional images. The required bone material volume was calculated about 0.9 cc in this preoperative analysis (Fig 9.).

Fig 9. Simulation of sinus graft

The mandibular bone harvesting on the anterior border of ascending ramus was planned with osteotomy using the surgical drill. In the simulation of osteotomy on the left mandibular ramus area the estimated bone volume that could be harvested was about 1.1 cc. The relationship between osteotomy area and inferior alveolar canal was evaluated carefully on the axial and sagittal views (Fig 10.).

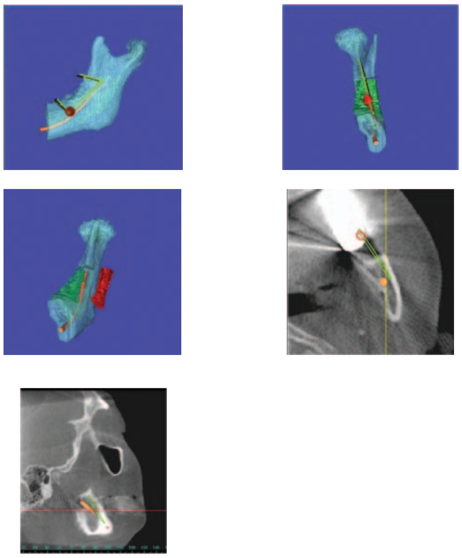


Fig 10. Simulation of osteotomy on the anterior border of ascending ramus

In the surgical procedure the osteotomy was conducted from the distal surface of second molar to the height of occlusal plane in the left mandibular ramus. The straight surgical bur was used for the osteotmy (Fig 11.).

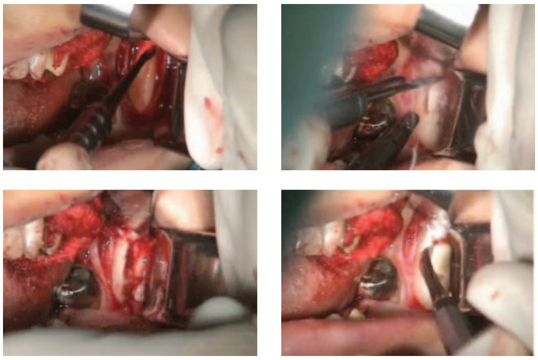


Fig 11. Surgical procedure

The volume of surgical defect also measured in this case. The amounts of harvested bone was measured about 1.4 CC which was sufficient for unilateral sinus graft. The surgical defect was distance from the inferior alveolar canal above 1.1 mm (Fig 12.).

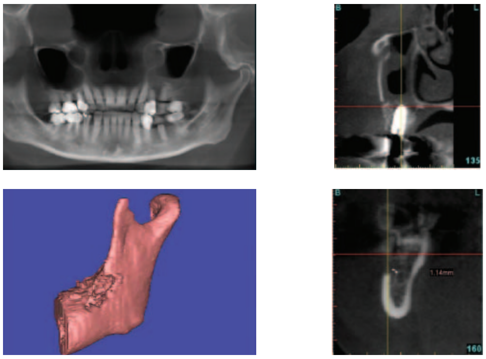


Fig 12. Postoperative CBCT image analysis

Ⅲ. Discussion

Harvesting bone from the ramus requires knowledge of the mandibular canal anatomy to prevent nerve injury. The mean anteroposterior width of the ramus is approximately 30 mm, with the mandibular foramen usually located about two-thirds from the anterior border[3]. Although the buccolingual position of the mandibular canal is variable, the distance from the canal to the inner aspect of the buccal cortex was found to be greatest at the distal half of the first molar [4]. The buccal cortex is typically 3-4 mm thick in this region[3]. Misch recommended If the inferior alveolar canal is positioned superiorly in relationship to the external oblique ridge or the ramus is less than 1 cm in width, then other donor sites should be considered[1]. Conventionally, the thickness of the ramus may be evaluated by intraoral palpation, an A-P cephalometric radiograph and a panoramic radiograph is essential in evaluating the posterior mandible as a donor site. However none of above diagnosis method is sufficient for evaluation of spatial relationship between door site to nerve canal. CBCT image analysis was very useful for estimate the position of inferior alveolar canal in preoperative planning.

The main limitation of intraoral bone graft is the limited supply of autogenous bone. The bone harvested from this area is well suited for one - to four - tooth edentulous span ridge augumentation. Gungormus and etc. reported that the average dimensions of the graft material obtained from the anterior part of ascending ramus were 37.60 x 33.17 x 22.48 x 9.15 mm; the average bone volume was 2.36 ml[5]. By using the function of CMS module in the Simplant™ software, the simulation of osteotomy could be possible on the anterior part of ascending ramus area without invasion of nerve canal. And then the volume of segmented block could be estimated in the simulaiton procedure. In the case of bone harvesting with trephine bur we could simulate surgical procedure by superimposing cylinder represents trephine bur on the 3-dimensional reconstructed mandible. Then cylinder volume calculated and the amount of harvesting bone material expected.

Ⅳ. Conclusion

The Pre-operative analysis using 3-dimensional reformatted images which produced by Cone Beam CT was very useful for preventing the neurovascular bundle injury and estimating grossly the amount of obtained graft bone material during the mandibular ramus bone harvesting.

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Abstract

하악지 골이식을 동반한 임프란트 식립시 CT영상의 활용

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연구목적 : 구강내의 골이식 채취부위로는 maxillary tuberosity, mandibular symphysis, anterior nasal spine 등이 있으나 채취하는 골의 양이 부족하거나 혹은 골 채취후 합병증의 가능성으로 인해 골 채취부위로서 한계가 있다. mandibular ramus에서의 골 채취는 비교적 합병증 발생가능이 적고 채취량이 많아 주목 받고 있다. 그러나 하악관 침범 가능성이 있어 시술에 주의를 기울려야 한다.

연구방법 : 리빙웰 치과병원에 임프란트 시술을 위해 내원한 환자중 하악지 골이식이 필요한 증례에서 CT영상을 이용하여 하악관의 위치와 채취량을 분석하였다. CT 촬영기로는 i-CAT™(imaging science international, USA)이 사용되었으며 촬영된 영상은 Simplant™ (materialize, Belgium) 소프트웨어의 CMF module을 이용하여 분석되었다.
결과 : 술전 CT영상 분석을 통하여 골 채취시 trephine bur혹은 surgical drill의 안전한 접근법에 대해 simulation 할 수 있었고 하악관의 주행과 비교해봄으로써 하악관을 침범하지 않는 안전한 부위를 입체적으로 확인할 수 있었다. 또한 채취될 골량을 미리 예측할 수 있어 임프란트 시술에 필요한 골량을 미리 확인 할 수 있었다.

결론 : 하악지 골이식을 동반한 임프란트 식립시 CT영상분석을 통하여 하악관을 침범하지 않는 안전한 골채취법을 simulation할 수 있었고 채취될 골량을 예측할 수 있었다.