The Value of 3-Dimensional Computed Tomography for Jaws Osteotomies

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Abstract: Three dimensional computed tomography (3D-CT) has been used widely in diagnosis and treatment for patients with jaw deformity. In present study, the author assessed the value of 3D-CT in jaw osteotomies. Anatomic measurement data from 3D-CT was used to guide surgical treatment. 42 patients with dentofacial deformity (28 females and 14 males) were selected as study group who underwent Le Fort I osteotomy with bilateral sagittal split ramus osteotomy or intraoral vertical ramus osteotomy (IVRO). The patients in study group were observed on 3D-CT acquired with a slice thickness of 1.25mm between June 2006 and June 2010. 20 patients were selected as control group who underwent the same osteotomy between June 2006 and June 2010. Patients in control group underwent X-rays such as panoramic film and cephalometric radiography but no anatomic measurements. The following anatomical data was measured for study group: 1. the distance from lingula mandibulae to anterior border of ramus, posterior border of ramus and inferior border of simoid notch; 2. the width between the outer mandibular canal and buccal side cortical bone at three location planes: the mandibular foramen plane (MFP), the mandibular angle plane (MAP) and the intermediate plane (MIP) between MFP and MAP; 3. the height of bilateral pterygomaxillary junction; 4. the anteroposterior distance from bilateral anterior nasal aperture to canalis pterygopalatinus. According to the anatomical data from 3D-CT, surgeons can take measures to avoid some complications during operation. As for study group, 42 patients satisfied with operation didn’t experience severe complications such as avascular necrosis, unexpected fracture and haemorrhage and so on. As for control group, 3 patients suffered from mandible fracture and 1 patient descending palatine artery blooding. All the results showed that 3D-CT was valuable for jaws osteotomies.

Keywords: Three-dimensional computed tomography, Sagittal split ramus osteotomy, Dentofacial deformity, Intraoral vertical ramus osteotomy

Introduction

The sagittal split ramus osteotomy (SSRO) of mandible was first introduced by Schuchardt1) in 1942, modified by Trauner2) and Obwegeser3) in 1957, and is now the most widely used orthognathic surgical procedure for the mandible. However, SSRO has also numerous complications, such as the lower lip hypoesthesia, unexpected fractures and so on. Intraoral vertical ramus osteotomy (IVRO) reported by Winstanley4) in 1968 is also a common surgical procedure for treating mandibular prognathism or mandibular asymmetry5), because of the predictable outcomes and the low complication rate6,7). IVRO offers several advantages, including ease of the procedure, absence of external facial scars, reduced surgical time, minimal incidence of facial and inferior nerve injury and bleeding8). As for maxilla, Le Fort I osteotomy is currently a popular technique for the correction and treatment of maxillofacial deformities. Although safe, various complications have been reported after surgery including excessive haemorrhage, maxillary artery bleeding, unexpected fracture and so on9). Recently, with the development of 3D-CT, manuscripts on clinical utility of 3D-CT imaging for the diagnosis and surgical treatment planning of patients with craniofacial deformities have been reported10). But most of manuscripts merely introduced how to obtain the diagnosis of jaws deformities under the help of 3D-CT and manuscripts on the application of 3D-CT on the treatment of jaws osteotomies weren’t too much. In present study, 3D-CT was used to collect anatomical data of maxilla and mandible before operation with two aims. On one hand, suitable approach for
operation could be selected and surgeons could find the safest site for osteotomies. On the other hand, some serious complications could be avoided for jaws osteotomies according to the basic data.

**Materials and Methods**

**Materials**

The present examination was a clinical radiographic data used in study which was ethically approved by institution. 62 patients with maxillofacial deformities collected retrospectively between June 2006 and June 2010 were divided into two groups: study group-42 patients and control group-20 patients. The patients in study group (28 females and 14 males) underwent 3D-CT examination and the ages of patients ranged from 18 to 34 years. As for 3D-CT examination, GE Lightspeed machine was used with the following scan parameters for all patients: the slice thickness of the reconstructed image, 1.25mm; the slice interval, 1mm; 120kV, average 391mA, 0.8s/rotation. Patients in control group (9 females and 11 males) underwent panoramic films and cephalometric radiography and the age ranged from 19 to 27 years. All the anatomic data was measured by two technicians and the mean data was reported to surgeons finally. The anatomical data of jaws was described as follows.

1. The distance from lingula mandibulae to anterior border of ramus, posterior border of ramus and inferior border of simoid notch (Fig. 1).
2. The width between the outer mandibular canal and buccal side cortical bone at three location planes: the mandibular foramen plane (MFP), the mandibular angle plane (MAP) and the mandibular body plane (MBP) (Fig. 2a, b, c).
3. The height of bilateral pterygomaxillary junction (Fig. 3a, b).
4. The anteroposterior distance from bilateral anterior nasal aperture to canalis pterygopalatinus (Fig. 4a, b).

**Application of 3-DCT for jaws osteotomies**

In the surgical team, two main surgeons who specialized in orthognathic surgery performed jaws osteotomies. The information obtained from 3-DCT could be translated into clinical practice as follows.

First of all, according to the distance from lingula mandibulae to posterior border of ramus, the surgeon could determine the longest setback amount of mandible for one side. For example, if the distance from right lingula mandibulae to posterior border of ramus was 19mm, the mandible setback amount couldn’t exceed it or the surgeon should think of performing additional maxilla osteotomy for the patient. When SSRO was performed, some doctors used drill to strip the medial cortical bone of ramus in order to observe lingula mandibulae for the reason that osteotomy line located above and behind lingula mandibulae. Stripping usually resulted in some complications such as severe swelling, infection and so on. For the surgeon, stripping the cortical bone needed much time. If the surgeon could find simoid notch during operation, lingula mandibulae would be located approximately according to the distance from lingula mandibulae to anterior border of ramus, and inferior border of simoid notch. Lingula mandibulae didn’t have to be seen clearly during operation and much operation time could be saved.

Secondly, according to the width between the outer mandibular canal and buccal side cortical bone at three location planes (MFP, MAP, MBP), the surgeon could select suitable operation for mandible. For example, if the width between the outer mandibular canal and buccal side cortical bone was too narrow for the patient, alternative procedure for mandible osteotomy was IVRO (Fig. 5).

**Results**

30 patients underwent Le Fort I osteotomy with BSSRO, 7 patients underwent Le Fort I osteotomy with BIVRO, 5 patients underwent Le Fort I osteotomy with SSRO for one side and IVRO for the other side. 6 patients underwent genioplasty. After the maxilla was down-fractured, the maxillary segment was then
Figure 2. The distance between mandibular canal and buccal side cortical bone at the level of three planes. 2a. mandibular foramen plane; 2b. mandibular angle plane; 2c. the mandibular body plane.

Figure 3. The height of bilateral pterygomaxillary junction. 3a. The left height of bilateral pterygomaxillary junction; 3b. The right height of bilateral pterygomaxillary junction.

Figure 4. The anteroposterior distance from bilateral anterior nasal aperture to canalis pterygopalatinus. 4a. The left anteroposterior distance from bilateral anterior nasal aperture to canalis pterygopalatinus; 4b. The right anteroposterior distance from bilateral anterior nasal aperture to canalis pterygopalatinus.
including the distance from the piriform rim to the descending palatine canal. As we know, the descending palatine artery was the largest vessel with a mean diameter of 1.7-4mm. It was the main cause of arterial bleeding during Le Fort I osteotomy. In our study, the height of the pterygomaxillary junction and the distance from the piriform rim to the descending palatine canal were measured by use of preoperative three dimensional computed tomography. The surgeon could approximately locate the descending palatine artery and internal maxillary artery during operation. For some cases, if the wisdom tooth was absent or needed to be pulled out during operation, the osteotomy line could go through tuberosity just behind the second molar at a suitable angle. One of our patients suffered from the descending palatine artery bleeding during operation because the surgeon didn’t pay much attention to artery when stripping posterior wall of maxillary sinus. The surgeon used electric coagulation to stop bleeding. The bone segments were placed in the planned position and stabilized with maxillomandibular fixation by using occlusal splint. The mini-plates were used to fix the bone segments and not fixation for IVRO. Elastic bands were placed to maintain ideal occlusion, and occlusal guide plates were abandoned 2 weeks after operation. All operations were performed by one surgical team, and all patients received routine preoperative and postoperative orthodontic treatments in School of Stomatology China Medical University.

None of the patients experienced severe complications such as abnormal bleeding, cranial nerve injury and the CSF leak. One patient who underwent SSRO experienced ramus fracture. Lower lip hypoesthesia appeared in 28 of 42 patients 1 week after operation. The symptom disappeared six months later except 3 patients with genioplasty.

**Discussion**

Osteotomy at the Le Fort I level was first described by Von Langenbeck in 1859. Cheever performed down fractures of total maxilla in order to remove nasopharyngeal and nasal neoplasms in 1867. Half a century later, Le Fort published his laboratory works on maxillary osteotomies in 1901. A few studies have reported the anatomy of posterior maxilla formed by a fusion of several bones: maxillary bone, palatine bone, pterygoid plates of the sphenoid bone. Turvey and Fonseca studied the height of the pterygomaxillary junction and the distance from the piriform rim to the descending palatine canal were measured by use of preoperative three dimensional computed tomography. The surgeon could approximately locate the descending palatine artery and internal maxillary artery during operation. For some cases, if the wisdom tooth was absent or needed to be pulled out during operation, the osteotomy line could go through tuberosity just behind the second molar at a suitable angle. One of our patients suffered from the descending palatine artery bleeding during operation because the surgeon didn’t pay much attention to artery when stripping posterior wall of maxillary sinus. The surgeon used electric coagulation to stop bleeding. The
patient didn’t suffer from maxillary segment necrosis. Maybe collateral circulation played important role in providing nutrition for maxillary segment. As for SSRO or IVRO, the most common conventional images used for the patient with craniofacial deformity are cephalometric and panoramic radiographs. Panoramic radiographs and cephalometric radiographs are also used to evaluate asymmetry, but it is difficult to make a distinction between right and left side anatomical landmarks on a lateral cephalometric view. In addition, the surgeon can’t obtain precise distance between mandibular canal and buccal side cortical bone on panoramic radiographs. 3D-CT could be used to provide three dimensional anatomical relationships between inferior alveolar nerve and cortical bone. A few studies have examined the position and course of mandibular canal in patients20). Tsuji et al.21) investigated the position and course of the mandibular canal through the mandibular ramus using computed tomographic imaging. The result suggested that the thickness of the mandible increased from the mandibular foramen to the mandibular body and the distance between mandibular canal and buccal side cortical bone was the thinnest at the level of the first and second molars. Ma Jia22) stated that the thickness of the mandible was thinner in mandibular hyperplasia patients than in the control patients. Therefore, it is very important for surgeons to conduct a SSRO operation on mandibular hyperplasia patients. Rajchel et al.23) reported on the anatomical bucco-lingual location of the mandibular canal using dried mandibles of adult Asians of unknown sex. They sectioned the dry mandibles at five locations perpendicular to the sagittal plane of the body of the mandible and found the greatest distance between the cortical plate and the mandibular canal was at the level of the first and second molars. But even if a vertical cut was made at the safest site with careful splitting, the inferior alveolar neurovascular bundle may still be encountered or impaired in patients with the mandibular canal and buccal side cortical bone was fused. Although the CT which could accurately reflect the anatomic structure of the mandible was used in this study and the surgeon could choose alternative procedure for the patient, the inherent complication such as lower lip hypesthesia resulting from inferior alveolar nerve damage was difficult to avoid. In our study, the lower lip hypesthesia appeared in 28 of 42 patients 1 week after operation. This kind of complication resulted from many multiple causal factors. Lower lip hypesthesia may result from medial traction of the neurovascular bundle during the medial horizontal ramus osteotomy, or due to entrapment of the nerve in the split itself, or due to inadvertent iatrogenic injury from chisels or other instruments. Intrusurgical neurolysis was probably the most important one no matter which procedure you performed. Among these patients, they who underwent genioplasty usually had lower lip hypesthesia, because mental nerve was easy to be damaged during operation. With respect to neurologic damage during surgery, it seems logical that IVRO would be preferable to SSRO24). In addition, many manuscripts reported the effectiveness of the 3D-CD for the diagnosis25,26,27). As we know, conventional X-rays were difficult to determine whether hidden asymmetries in the posterior regions were caused by dental or skeletal factors or both. Improper head positioning could also lead to inaccurate analysis. Yoon AK et al.29) used three-dimensional cone-beam computed tomography to evaluate facial asymmetry and obtained the conclusion that 3D-CBCT was a simple and efficient tool for assessing asymmetry. Lucia HS30) used cone-beam computerized tomography to have three-dimensional quantification for patients with mandibular asymmetry. Mandibular asymmetry can be precisely quantified under the help of CT. Therefore, 3D-CT is a valuable method for jaws osteotomies. From this study, we can get a conclusion that using preoperative measurements based on 3D-CT to guide jaws osteotomies can avoid some complications. We hope that this study may have a limited role in carrying out operation for patients with maxillofacial deformities (Fig. 6). In conclusion, it is very valuable for preoperative measurements we obtained based on 3D-CT to guide jaws osteotomies. Enough preparation before operation can decrease the ratio of complication of osteotomy.

Reference
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