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Changes in computed tomography values of mandibular condyle and temporomandibular joint disc position after sagittal split ramus osteotomy

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ABSTRACT

Purpose: The purpose of this study was to evaluate change in computed tomography (CT) value of condyle and temporomandibular joint (TMJ) disc position after sagittal split ramus osteotomy (SSRO) setback surgery, retrospectively.

Subjects and methods: The subjects were 76 patients (152 condyles) who underwent bilateral SSRO setback surgery. They were divided into 2 groups (43 symmetric patients and 33 asymmetric patients). CT values (pixel values) of 5 sites of the condyle and condylar width, length, horizontal angle were measured pre-operatively and 1 year post-operatively. Disc position was classified as anterior disc displacement, anterior type, fully covered type and posterior type, preoperatively and postoperatively using magnetic resonance imaging (MRI).

Results: In maximum CT value at the center of the condyle, post-operative value was significantly lower than pre-operative value bilaterally (Deviation side: $P = 0.0003$, Non-deviation side: $P = 0.0003$) in asymmetry group. In minimum CT value at the center of the condyle, the post-operative value was significantly lower than the pre-operative value bilaterally (Deviation side: $P = 0.0309$, Non-deviation side: $P = 0.0004$) in the symmetry group.

With regard to maximum CT value at the lateral site of the condyle in the deviation side, the value for the anterior disc displacement group was significantly larger than that of the posterior type pre-operatively ($P = 0.0123$). CT value of the anterior disc displacement group was significantly larger than those of some other areas pre- and post-operatively ($P < 0.05$).

Conclusion: This study suggested that CT value of condylar bone changes after 1 year in SSRO and anterior disc displacement may partially affect the CT value of the condyle in the TMJ in mandibular prognathism patients.

1. Introduction

Sagittal split ramus osteotomy (SSRO) is frequently used for the correction of jaw deformities (Trauner and Obwegeser, 1957). One advantage of this procedure is that large areas of bony contact that are made remain after either advancement or retrusion of the distal segment. However, making a wider bony contact without the step of the cortical bone surface between the proximal and distal segments can induce inward-rotation of the condylar long axis in setback surgery (Ueki et al., 2001, 2008a, 2008b). Alterations in condylar position from surgery can lead to malocclusion associated with the risk of early relapse (Leonard, 1976; Harada et al., 1996), and also favor the development of temporomandibular disorders (TMD) (Isberg and Isacsson, 1986; Ellis and Hinton, 1991; Rotskoff et al., 1991). For these reasons, several positioning devices have been proposed and applied, but generally do not provide better long-term outcomes in either mandibular advancement or setback surgery (Gerressen et al., 2006).

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Dentofacial deformity is associated with variations in TMJ including disc position. By using magnetic resonance imaging (MRI) the joints in prognathism patients could be classified into four types on the basis of disc position and shape: anteriorly displaced disc, the anterior type, the fully-covered type, and the posterior type (Ueki et al., 2000). The incidence of internal derangement in asymmetrical prognathia patients is higher than in symmetrical mandibular prognathia, and this finding is associated with a difference in TMJ morphology of both sides (Ueki et al., 2000). Furthermore, a previous study suggested that the masseter muscle area did not significantly differ from the preoperative status 1 year after SSRO, although postoperatively 1 year ramus width, ramus area and condylar area were significantly larger than the preoperative values (Ueki et al., 2009a, 2009b). However, there is no study on change in condylar bone quality following SSRO.

CT value can be correlated to bone density, and bone strength can be expressed by bone density and quality (Lettry et al., 2003). The date of obtaining the CT value can be useful in determining bone formation. The purpose of this study was to evaluate change in computed tomography (CT) value of the condyle and disc position after sagittal split ramus osteotomy (SSRO) set-back surgery, retrospectively.

2. Patients and methods

2.1. Patients

Seventy six Japanese patients (men: 22, women: 54) presenting with jaw deformities diagnosed as mandibular prognathism with and without maxillary deformity were enrolled in the study. At the time of orthognathic surgery, the patients ranged in age from 16 to 52 years, with a mean age of 28.3 years (standard deviation, 10.9 years). Although this was a retrospective study, informed consent was obtained from the patients. Surgeries were performed from 2000 to 2013 at Kanazawa University Hospital and University of Yamanashi Hospital.

All patients were examined with lateral and frontal cephalograms. The cephalograms were entered into a computer and analyzed using appropriate computer software (Cephalometric Ato Z, Yasunaga Labo Com, Fukui, Japan). All patients were diagnosed objectively as skeletal Class III from the cephalometric measurements. On the frontal cephalogram, the angle between the ANS-Menton line and a line perpendicular to the bilateral zygomatic frontal suture line was defined as the Mx-Md midline angle. A positive value for this represented mandibular deviation to the left and a negative value, mandibular deviation to the right. The Mx-Md midline angles of all cases were then given a positive value so that all consecutive measurements could be attributed to either a deviated or non-deviated side (Ueki et al., 2000). The subjects were divided into a symmetry or asymmetry group according to the Mx-Md midline. The asymmetry group consisted of 33 patients whose Mx-Md midline was >3°, and the remaining 43 made up the symmetric group.

2.2. Surgery

Before surgery, lateral, frontal, and submento-vertex (S-V) cephalograms were obtained as described previously (Ueki et al., 2001, 2008a, 2008b). All 76 patients underwent bilateral SSRO setback with the modified fixation (Ueki et al., 2001, 2008a, 2008b).

Of the 76 patients in this study, 54 underwent bilateral SSRO. The remaining 22 patients underwent SSRO and a Le Fort I osteotomy; rigid fixation was achieved with min-plates and monocortical screws. After surgery, elastic bands were placed to maintain an ideal occlusion. All patients received orthodontic treatment before and after surgery. CT scan was performed for all patients preoperatively, and 1 year after surgery.

2.3. CT data acquisition

The patients were placed in the gantry with the tragacanthal line perpendicular to the ground for CT scanning. They were instructed to breathe normally and to avoid swallowing during the scanning process. CT scans were performed in the radiology department by skilled radiology technicians using a high-speed, advantage-type CT generator (Light Speed Plus; GE Healthcare, Milwaukee, WI, USA) with each sequence taken 1.25 mm apart for 3D reconstruction (120 kV, average 150 mA, 0.7 s/rotation, helical pitch 0.75). The resulting images were stored in the attached workstation computer (Advantage workstation version 4.2; GE Healthcare, Milwaukee, WI, USA) and the 3D reconstruction was performed using the volume rendering method. Zed View version 7.0 (LEXI Co, Tokyo, Japan) medical imaging software was used for 3D morphologic measurements.

The right-left (RL) line was determined as the line between the most anterior points of the bilateral auricles at the plane parallel to the Frankfort horizontal (FH) plane. Multi planner reconstruction can be established in the software, so that the arbitrary plane can be moved parallel to the plane that the RL line was determined. The items below were measured (Fig. 1).

1) Condylar length: The distance between the most medial point and most lateral point of the ramus on the plane parallel to FH where maximum area of the condyle was recognized.
2) Condylar width: the thickest distance perpendicular to the condylar length on the parallel plane to FH where maximum area of the condyle was recognized.
3) Condylar angle: the angle between the RL line and the condylar long axis (the line between the most medial and lateral points).

CT image analysis software (Diana DICOM free version 1,8,1,6, Luke System, Chiba, Japan) was used to measure CT value (pixel value). CT values of the condyle were measured preoperatively and at 1 year postoperative using horizontal images where the condylar square was maximum at the mandibular foramen parallel to the FH plane of the CT image. Using one image fore-mentioned, 5 areas were selected and measured at the anterior site (area 1), center site (area 2), posterior site (area 3), lateral site (area 4) and medial site (area 5). The maximum, minimum and mean pixel values in the regions of interest (ROI) with approximately 10 mm^2 rectangle were measured automatically three times (Fig. 2). Furthermore, the mean value was calculated and determined as pixel value in each part.

CT values of all CT images were measured by an author (K.U.). Fifteen condyles were selected and the calculation performed using Dahlberg's formula (Dahlberg, 1940):

$$ME = \sqrt{\sum d^2/2n}$$

where d is the difference between 2 registrations of a pair, and n is the number of double registrations. The random errors did not exceed 23 for the pixel value measurements.

2.4. MRI assessment

A detailed MRI assessment of each pair of TMJs was performed by a 1.5-T MRI system (Signa Scanner, General Electric Medical Systems, Milwaukee, WI, USA), using bilateral 3-inch dual surface coils with the jaw first in the closed, resting position and then at its