Changes in temporomandibular joint and ramus after sagittal split ramus osteotomy in mandibular prognathism patients with and without asymmetry

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Changes in the temporomandibular joint and ramus after sagittal split ramus osteotomy in mandibular prognathism patients with and without asymmetry

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Abstract

The purpose of this study was to examine the changes in the temporomandibular joint (TMJ) and ramus after sagittal split ramus osteotomy (SSRO) with and without Le Fort I osteotomy.

The subjects consisted of 87 Japanese patients diagnosed with mandibular prognathism with and without asymmetry. They were divided into 2 groups (42 symmetric patients and 45 asymmetric patients). The TMJ disc tissue was assessed by magnetic resonance imaging (MRI) and the TMJ space, condylar and ramus angle were assessed by computed tomography (CT) preoperatively and postoperatively.

Medial joint space on the deviation side in the asymmetry group was significantly larger than that in the symmetry group ($P=0.0043$), and coronal ramus angle on the non-deviation side in the asymmetry group was significantly larger than that in the symmetry group preoperatively ($P=0.0240$). The horizontal condylar angle on the deviation side in the asymmetry group was significantly larger than that in the symmetry group ($P=0.0302$), posterior joint space on the non-deviation side in the symmetry group was significantly larger than that in the asymmetry group postoperatively ($P=0.00391$).

The postoperative anterior joint space was significantly larger than the preoperative value on both sides in both groups (the deviation side in the symmetry group: $P=0.0016$, the non-deviation side in the symmetry group: $P<0.0001$, the deviation side in the asymmetry group: $P=0.0040$, the non-deviation side in the asymmetry group: $P=0.0024$). The preoperative disc position could was not changed in either group.

These results suggest that significant expansion of anterior joint space could occur on the deviation side and non-deviation side in the asymmetry group as well as on both sides in the symmetry group, although disc position did not change in either group.

Key words:

Temporomandibular joint space

Sagittal split ramus osteotomy

Mandibular prognathism

Asymmetry

Introduction

The purpose of this study was to compare the changes in temporomandibular joint (TMJ) morphology and ramus and clinical symptoms after SSRO with and without a Le Fort I osteotomy, in mandibular prognathism with and without asymmetry.

Sagittal split ramus osteotomy (SSRO) is a standard surgical technique for the correction of jaw deformities (Trauner & Obwegeser, 1957). Alterations in condylar position from surgery can lead to dysocclusion associated with the risk of early relapse (Leonard, 1976; Harada et al., 1996), and also favour the development of temporomandibular disorders (TMD) (Isberg & Isacsson, 1986; Ellis & 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).

Dentofacial deformity is associated with variations in the 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 difference is associated with a difference in TMJ morphology of both sides (Ueki et al., 2000). Furthermore, in the asymmetry case, interference between the proximal and distal segments can occur so that the determination of postoperative condylar position could be difficult (Ellis, 2007). It is therfore necessary that the subjects are divided into a symmetry group and an asymmetry group, and the TMJ and ramus investigated after SSRO.

Patients and Methods

Patients

The 87 Japanese adults (men: 27, women: 60) in this retrospective study presented with jaw deformities diagnosed as mandibular prognathism with and without asymmetry, with and without maxillary deformity. At the time of the orthognathic surgery, the patients ranged in age from 16 to 48 years, with a mean age of 28.0 years (standard deviation, 9.9 years). Informed consent was obtained from the patients and the study was approved by Kanazawa University Hospital.

All patients were examined with lateral and frontal cephalograms. The cephalograms were entered into a computer and analysed 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 45 patients whose Mx-Md midline was >3 degrees, and the remaining 42 made up the symmetric group.

Surgery

Thirteen of 42 patients (men: 12, women: 30, mean age: 28.4 years, standard deviation: 9.9years) in the symmetry group underwent bilateral SSRO with Le fort I osteotomy, the other 29 patients underwent bilateral SSRO. On the other hand, 21 of 45 patients (men: 15, women: 30, mean age: 28.0, standard deviation: 10.0 years) underwent SSRO with Le Fort I osteotomy, the other 24 patients underwent bilateral SSRO. When the proximal and distal segments are fixed with straight plates after setback surgery, the proximal segments containing the condylar head cause internal rotation. Thus, it was assumed that the use of bent plates was the most efficient and simple method to prevent internal rotation of the proximal segments (Fig. 1) (Ueki et al., 2008). Although the condylar positioning device (CPD) was not used in all cases, condylar position was checked by radiography (Schüller method in closing mouth). In all the patients, rigid fixation was achieved with mini-plates and monocortical screws. Inter-maxillary fixation immediately after surgery was not performed, and elastic traction was placed to maintain the ideal occlusion. All patients received orthodontic treatment before and after surgery. All subjects were assessed with CT before surgery and at 1 year after surgery, and with MRI before surgery and at 6 months after surgery. Objective TMJ symptoms were recorded and evaluated.

CT measurement

CT was taken for all patients preoperatively and one year after surgery. 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 obtained 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 sec/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. ExaVision LITE version 1.10 medical imaging software (Ziosoft, Inc, Tokyo, Japan) was used for 3D morphologic measurements (Ueki et al.,2011)

The horizontal slice image parallel to the FH (Frankfurt horizontal) plane where two condyles could be recognized at maximum square (including medial and lateral pole of the condyle) was selected to measure the condylar angle. The RL line was determined as the line between the most anterior points of the bilateral auricles (Fig. 2).

1) Horizontal condylar angle: the angle between the RL line and the condylar long axis (the line between the most medial and lateral points).

The following items were measured in the coronal image (the plane perpendicular to the Frankfurt horizontal (FH) plane and parallel to the condylar long axis).

The condylar centre point (CP) was defined as the exact midpoint between the most medial or lateral point and the opposite point across the condylar outline on the parallel line to the FH plane. Joint space was determined as the distance between the point on the articular fossa line and the point on the condylar surface outline on the line going through the CP within the overlapped area of the articular fossa line and the condylar surface outline (Fig. 3).

2) Coronal condylar angle: the angle between the FH plane and the condylar long axis (the line between the most medial and lateral points).

3) Coronal ramus angle: the angle between the FH plane and the tangential line to the lateral outline of ramus.

4) Medial joint space: the distance at the most medial point of the condyle or the articular fossa.

5) Lateral joint space: the distance at the most lateral point of the condyle or the articular fossa.

The sagittal image perpendicular to the FH plane including the condylar head and mandibular angle was selected to measure as follows (Fig. 4).

6) Sagittal ramus angle: the angle between the FH plane and the tangential line to the posterior outline of ramus.

7) Anterior joint space: the distance parallel to the FH plane between the most anterior point of the condyle in the articular fossa and the articular eminence outline.

8) Superior joint space: the distance perpendicular to the FH between the most superior point and the articular fossa outline.

9) Posterior joint space: the distance parallel to the FH plane between the most posterior point of the condyle in the articular fossa and the articular fossa outline.

All CT images were measured by an author (K.U.). Fifteen patients were selected and the calculation performed using the 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 0.21 mm for the linear measurements.

MRI assessment

A detailed MRI assessment of each pair of TMJs was performed by a 1.5-tesla 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 maximally opened position. An initial axial localiser was introduced to obtain the exact midcondylar sections perpendicular and parallel to the long axis of each condyle. Images of the bilateral orthogonal sagittal planes and coronal planes of the TMJs in the closed jaw position were acquired first with a repetition pulse (TR) of 2000 msec, echo times (TEs) of 20 msec, a 3-mm image slice thickness, and a field of view of 10 cm. Then images of the bilateral sagittal planes of the TMJs in the open mouth position were obtained with a TR of 1000 msec and TEs of 20 msec.

Images of the midcondylar slices perpendicular and parallel to the long axis of each condyle were entered into a computer (PC9821Xa13, NEC, Tokyo, Japan) with a scanner (GT9500, Epson, Tokyo, Japan) and the coordinates of the highest point of the condyle were determined with Scion Image software (Scion Corporation, Frederick, Maryland, USA).

In the sagittal plane images, the centre point was determined to be the midpoint of the antero-posterior length of the condyle on the line between the lowest point of the articular eminence and the squamotympanic fissure. The lowest point of the articular eminence was considered to be 0° and the squamotympanic fissure became 180°.

Definitions

All joint discs were classified according to the following definitions, as shown in the previous report (Ueki et al., 2000).

Anterior disc displacement with and without reduction (ADDwR and ADDwoR): the entire disc is antero-inferior to the most anterior point on the contour of the condyle.

Anterior type: the centre of the intermediate zone is between 0° and 90° and the most posterior point of the posterior band is postero-superior to the most anterior point on the contour of the condyle and less than 180°.

Fully-covered type: the most anterior point of the anterior band is less than 0° and the most posterior point of the posterior band is greater than 180°.

Posterior type: the most anterior point of the anterior band is more than 0° and the most posterior point of the posterior band is greater than 180° (Fig. 5).

Statistical analysis

Data were compared between the pre and postoperative values, and between the deviation and non-deviation sides by paired t-test; between the symmetry and asymmetry groups by non-paired t-test using the Dr. SPSS II (SPSS Japan Inc., Tokyo, Japan). The differences were considered significant at $p<0.05$.

Results

After surgery, no patient had wound infection or dehiscence, bone instability or non-union, or long-term dysocclusion. The mean setback amount was 6.6 ± 3.0 mm on the deviation side and 7.1±3.2 mm on the non-deviation side in the symmetry group and 5.0±3.4 mm on the deviation side and 7.8±3.4 mm on the non-deviation side in the asymmetry group. Although the setback amount on the deviation side in the asymmetry group was significantly smaller than that on the deviation side in the symmetry group (P=0.0302), and the non-deviation side in the asymmetry group (P<0.0001). There was no significant difference between both sides in the symmetry group. The difference in the setback amount in the asymmetry group was considered reasonable.

CT data

The medial joint space on the deviation side in the asymmetry group was significantly larger than that in the symmetry group (P=0.0043), and the coronal ramus angle on the non-deviation side in the asymmetry group was significantly larger than that in the symmetry group preoperatively (P=0.0240). The horizontal condylar angle on the deviation side in the asymmetry group was significantly larger than that in the symmetry group (P=0.0302), the posterior joint space on the non-deviation side in the symmetry group was significantly larger than that in the asymmetry group postoperatively (P=0.00391).

In the comparison between pre and postoperative values in the symmetry group, the postoperative value was significantly larger than the pre-operative value in sagittal ramus angle on the deviation side (P=0.0106), anterior joint space (P= 0.0016) and posterior joint space on the deviation side (P=0.0018). Similarly, the postoperative value was significantly larger than the pre-operative value in the anterior joint space (<0.0001), superior joint space (P=0.0412) and posterior joint space on the non-deviation side (P=0.0007).

In the comparison between pre and postoperative values in the asymmetry group, the postoperative value was significantly smaller than the pre-operative value in the coronal condylar angle on both sides (the deviation side: P=0.0051 and the non-deviation side: P<0.0001). The postoperative value was significantly larger than the preoperative value in the anterior joint space on both sides (the deviation side: P=0.0040 and the non-deviation side: P=0.0024).

In the comparison between the deviation and non-deviation sides, there was no significant difference in any measurements pre and postoperatively in the symmetry group, but the coronal ramus angle on the deviation side was significantly smaller than that on the non-deviation side preoperatively (P<0.0001) and postoperatively (P=0.0359). The anterior joint space on the deviation side was significantly smaller than that on the non-deviation side preoperatively (P=0.0205) and postoperatively (P=0.0350) (Table 1).

Disc position

The anterior type and fully-covered type were dominant in the symmetry and asymmetry groups. In the distribution of disc classification, there was a significant difference between the sides in both groups (P=0.0310). When the subjects were divided into anterior disc displacement and so on (anterior type, fully-covered type, or posterior type), there were significant differences between the deviation side in the symmetry group and the deviation side in the asymmetry group (P=0.0036), and between the deviation side and non-deviation sides in the asymmetry group (P=0.0274).

Joints classified preoperatively as anterior type, fully-covered type, or posterior type showed no postoperative changes in the symmetry and asymmetry groups.

Preoperative ADDwR and ADDwoR did not change postoperatively in the symmetry and asymmetry groups.

TMJ symptoms

The preoperative TMJ symptoms most frequently reported were abnormal sound (clicking and crepitus) and slight pain when opening the mouth; none of the patients reported trismus. Symptoms were improved by surgery in 71.4 % on the deviation side and 72.4 % on the non-deviation side in the symmetry group, and in 73.3 % on the deviation side and 61.5 % on the non-deviation side in the asymmetry group, however, no statistically significant difference was found between the sides in either group.

Condylar resorption was found in 2 joints with ADDwR and ADDwoR on the deviation side in the asymmetry group and 1 joint with ADDwR on the non-deviation side in the asymmetry group. However, these joints did not show postoperative symptoms and mal-occlusion.

When the subjects were divided into SSRO and SSRO with Le Fort I osteotomy, there was no significant differences between the two groups in all measurements.

Discussion

Signs and symptoms of TMJ dysfunction have previously been studied in patients with dentofacial deformities (Laskin et al., 1986; Kerstens et al., 1989; White & Dolwick, 1992; Link & Nickerson, 1992). Fernandez Sanroman et al. (1998) found that the incidence of disc displacement was 11.1% for the class I anterior open-bite group and 10% for the class III group. When the class II group was studied, an ADD was diagnosed in 15 of the 28 joints (53.6%). Schellhas et al. (1992) have studied 100 patients with a retrognathic facial skeleton, examining the TMJs with MRI for signs of moderate to severe pathology. In short, a class II dentofacial deformity is reportedly strongly associated with moderate to severe TMJ pathology or an ADD. On the other hand, temporomandibular joint internal derangement (TMJ ID) is widely reported to be associated with mandibular asymmetry. Schellhas et al. (1990) suggested that disc displacement, internal derangement (ID), or degenerative joint disease could be a main cause of mild and moderate mandibular asymmetries. Various studies have investigated occlusal problems as a predisposing factor for TMJ ID. Occlusal instability, midline discrepancy, right-left differences in molar relationship, and inclination of the frontal occlusal plane have been considered to be important occlusal characteristics in patients with TMJ disorders (Solberg et al., 1986; Fushima et al., 1999). Differences in the heights of the right and left rami, have also been suggested as important skeletal problems associated with TMJ pathology (Inui et al., 1999; Trpkova et al., 2000). A similar tendency has been recognised in mandibular prognathism with asymmetry (Ueki et al., 2000), although the incidence of TMJ dysfunction in mandibular prognathism is lower than in mandibular retrognathism (Fernandez Sanroman et al,. 1998). These results suggest that asymmetry increases the occurrence of TMJ dysfunction with an ADD. The incidence ratio of ADD on the deviation side was higher than the nondeviation side. It was therefore very important that the subjects were divided into a symmetry group and an asymmetry group and investigated in the TMJ and ramus after SSRO.

This study also showed that the incidence of ADD was significantly higher on the deviation side in the asymmetry group. Anterior type and the fully-covered type were dominant on both sides in the symmetry and the non-deviation side in the asymmetry. This suggested that the patients with severe prognathism had TMJ's with the fully-covered type disc. The deviation side in the asymmetry group might show TMJ morphology of a Class II tendency. The joints and their disc tissue adapt to the individual skeletal morphology in these cases. Our previous study demonstrated that temporomandibular joint (TMJ) stress was associated with TMJ morphology in Class III patients regardless of whether they were asymmetric using rigid body spring theory model (Ueki et al., 2005). Correlation between classification and stress angulation indicated that the stress direction of the anterior displaced or anterior type disc was more anterior to the condyle. On the other hand, the stress directions of the fully-covered and posterior types had a tendency to be more superior to the condyle. In other words, disc position and morphology were related to stress distribution.

Regarding the TMJ clicking sound, not all patients with clicking sounds have ADD with reduction; nor do all patients with clicking sounds have deviation in form of the articular surfaces (Oster et al., 1984). Patients with the anterior type, fully-covered type and posterior type disc can also have clicking sounds. In such cases, when the condyle moved beyond the anterior hypertrophic part of the disc, the sound occurred. This may be characteristic in mandibular prognathism and the non-deviated side in mandibular asymmetry.

Fang et al. (2009) also reported that there was no significant difference in disc length with MRI between the pre- and postoperative states in 24 skeletal Class III patients, although it was unclear whether these subjects included the asymmetry cases. In this study of Class III patients, we found no improvement in disc displacement after SSRO with and without Le Fort I osteotomy, in the symmetry group and asymmetry group.

Orthognathic surgery such as SSRO may cause changes in the condylar position, so the position of the condyle must be monitored. However, the disc-condyle relationship is a more important parameter in assessing changes in TMJ morphology and symptoms. Many researchers, using different radiographic methods, have studied the movements of the condyle that occur in patients who undergo orthognathic surgery.

Freihofer and Petresevic (1975), in a radiographic study of 38 patients who underwent SSRO for mandibular advancement, showed that 10 of 26 condyles appeared to be positioned anteriorly in the glenoid fossa. Will et al. (1984) similarly found that both condyles were positioned posteriorly in 41 patients who underwent SSRO to advance the mandible. However, in their study of 15 patients, Hackney et al. (1989) found no correlation between the amount of mandibular advancement and changes in condylar position or mandibular shape. In SSRO, rigid fixation of the mandible may create a greater change in the position of the condyle and a higher incidence of TMJ dysfunction compared with nonrigid fixation (Buckley et al. 1989).

In the review of Costa et al (2008), three studies supported the use of CPDs (Rotskoff et al., 1991; Helm & Stepke, 1997;Landes & Sterz, 2003; Renzi et al. 2003), but only 1 (Landes & Sterz, 2003) supported their application to improve clinical outcome concerning TMJ function and skeletal stability. One study (Renzi et al. 2003), which was limited to class III malocclusions, supported the use of CPDs only in the case of TMD. Two studies did not support the use of CPDs, because they failed to improve skeletal stability or TMJ function, irrespective of the skeletal deformities treated. The condylar position could not be completely reproduced even if the CPD was used, although there was significant difference between with and without CPD groups.

Westesson et al. (1991) found that the mean horizontal condylar angle was most acute in joints with a normal superior disc position (mean 21.2 degrees) and was less so in joints with disk displacement (29.7 degrees for disk displacement without reduction) and/or with degenerative joint disease (36.5 degrees). Fernandez Sanroman et al. (1998) found that the mean horizontal condylar angle in the Class II group was significantly larger than that in the control group, and that the larger condylar angle can be an aetiological factor for disc displacement and degenerative joint disease. Our previous study also showed a mean horizontal condylar angle for the Class III symmetry group of 12.0 degrees on the right and

11.8 degrees or the left (Ueki et al., 2000). From these reports, if the skeletal pattern is different, TMJ morphology including condylar long axis will also be different. In short, change of occlusion and skeleton may induce a change in the condylar long axis. This study also showed that the horizontal condylar angle on the deviation side in the asymmetry group was significantly larger than that in the symmetry group.

The medial joint space on the deviation side in the asymmetry group was significantly larger than that in the symmetry group, and the coronal ramus angle on the non-deviation side in the asymmetry group was significantly larger than that in the symmetry group preoperatively. These findings suggested that the entire mandible tended to move to the deviation side, and the opening path when the mandible is in motion also tends to do likewise in asymmetry cases.

There was no significant difference in any of the measurements between both sides pre and postoperatively in the symmetry group. However, in the asymmetry group, the coronal ramus angle on the deviation side was significantly smaller than that on the non-deviation side preoperatively and postoperatively. These suggested that preoperative ramus asymmetry in the coronal plane existed in the asymmetry group, as well as TMJ asymmetry. Moreover, SSRO could not alter the ramus inclination in the coronal plane and the asymmetry of the ramus could improve.

In the previous study, the horizontal condylar long axis increased significantly on the right side and showed a tendency to be larger on the left side in SSRO group and on both sides of the SSRO with Le Fort I osteotomy group. Kim et al. (2010) also reported that the condyle on the axial plane rotated inward and maintained that position during the post-retention period. When a 3-5 mm gap was made between the proximal and distal segments and a bent plate was fixed with 4 screws on each side of the mandible in SSRO, there were no significant differences between the pre- and postoperative horizontal changes in the condylar long axis or in the antero-posterior and medio-lateral displacements of the condylar head (Ueki et al., 2008). In this study, a similar method using bent plate fixation was used in the symmetry and asymmetry groups, so that the horizontal condylar angle could not change significantly. Instead, the postoperative coronal condylar angle was significantly smaller than the pre-operative value on both sides. This might indicate a lateral expansion of the proximal segment at the mandibular angle region. In the study by Kim et al.(2010), the altered antero-posterior condylar position in the glenoid fossa after SSRO with rigid fixation moved from a concentric to an anterior position in the post-retention period. The actual value of the joint space was measured in this study, so it will be difficult to compare with their results. Thr postoperative anterior joint space was significantly larger than the preoperative value on both sides in the symmetry and asymmetry groups. However, such a postoperative expansion of joint space might be too small to change the disc position, although the incidence of postoperative TMJ symptoms decreased.

Interestingly, progressive condylar resorption was found in 3 joints with ADDwR or woR in the asymmetry cases in this study. The incidence of progressive condylar resorption after mandibular advancement has been reported to vary from 1% to 31 %. It was related to dysfunction of the TMJ, mandibular hypoplasia with a wide mandibular plane angle, a low posterior/anterior facial height ratio, or a posteriorly inclined condylar neck, or both (Kerstens et al., 1990; Moore et al., 1991; Bouwman et al., 1994; De Clercq et al., 1994; Hwang et al., 2004). There are no reports on condylar resorption after mandibular setback surgery. However, the results in this study suggested that condylar resorption could occur in setback surgery for the correction of mandibular asymmetry.

Conclusion

This study suggested that significant expansion of the anterior joint space could occur on the deviation and non-deviation sides in the asymmetry group as well as on both sides in the symmetry group. In addition, the change in disc position including ADD could not be expected in the symmetry and asymmetry groups after SSRO with and without Le Fort I osteotomy, although there was improvement in the TMJ symptoms.

References

Bouwman JP, Kerstens HC, Tuinzing DB: Condylar resorption in orthognathic surgery. The role of intermaxillary fixation. Oral Surg Oral Med Oral Pathol 78: 138-4, 1994.

Buckley MJ, Tulloch JF, White RP Jr, Tucker MR: Complications of orthognathic surgery: a comparison between wire fixation and rigid fixation. Int J Adult Orthodn Orthognath Surg 4: 69-74,1989.

Costa F, Robiony M, Toro C, Sembronio S, Polini F, Poli M: Condylar positioning devices for orthognathic surgery: a literature review. Oral Surg Oral Med Oral PatholOral Raiol Endod 106: 179-90, 2008.

Dahlberg G: Statistical methods for medical and biological students. George Allen and Unwin, London, pp. 122-132. 1940.

De Clercq CA, Neyt LF, Mommaerts MY, Abeloos JV, de Mot BM: Condylar resorption in orthognathic surgery: a retrospective study. Int J Adult Orthodon Orthognath Surg 9: 233-40, 1994.

Ellis E 3rd, Hinton RJ: Histologic examination of the temporomandibular joint after mandibular advancement with and without rigid fixation: An experimental investigation in adult Macaca mulata. J Oral Maxillofac Surg 49: 1316-27, 1991.

Ellis E 3rd. A method to passively align the sagittal ramus osteotomy segments. J Oral Maxillofac Surg 65: 2125-30, 2007.

Fang B, ShenGF, Yang C, Wu Y Feng YM, Mao LX, Xia YH: Change in condylar and joint disc position after bilateral sagittal split ramus osteotomy for correction of mandibular prognathism. Int J Oral Maxillofac Surg 2009; 38: 726-30.

Fernandez Sanroman J, Gomez Gonzalez JM, del Hoyo JA: Relationship between condylar position, dentofacial deformity, and temporomandibular joint dysfunction: an MRI and CT prospective study. J Cranio-Maxillofac Surg 26:35-42, 1998.

Freihofer HP Jr, Petresevic: Late results after advancing the mandible by sagittal splitting rami. J Maxillofac Surg 3:250-7, 1975.

Fushima K, Inui M, Sato S: Dental asymmetry in temporomandibular disorders. J Oral Rehabil 26: 752-6, 1999.

Gerressen M, Zadeh MD, Stockbrink, Riediger D, Ghassemi A: The functional long-term results after bilateral sagittal split osteotomy (BSSO) with and without a condylar position device. J Oral Maxillofac Surg 64:1624-30, 2006.

Hackney FL, Van Sickels JE, Nummikoski PV: Condylar displacement and temporomandibular joint dysfunction following bilateral sagittal split osteotomy and rigid fixation. J Oral Maxillofac Surg 47: 223-7, 1989.

Harada K, Okada Y, Nagura H, Enomoto S: A new condylar positioning appliance for two-jaw osteotomies (Le Fort I and sagittal split ramus osteotomy). Plast Reconstr Surg 98:363-5, 1996.

Helm G, Stepke MT: Maintenance of the preoperative condyle position in orthognathic surgery. J Craniomaxillofac Surg 25: 34-8, 1997

Hwang SJ, Haers PE, Seifert B, Sailer HF: Non-surgical risk factors for condylar resorption after orthognathic surgery. J Craniomaxillofac Surg 32: 103-11, 2004.

Isberg AM, Isacsson G: Tissue reactions of the temporomandibular joint following retrusive guidance of the mandible. Cranio 4:143-8, 1986.

Inui M, Fushima K, Sato S: Facial asymmetry in temporomandibular disorders. J Oral Rehabil 26: 402-406, 1999.

Kerstens HCJ, Tuinzing DB, van der Kwast WAM: Temporomandibular joint symptoms in orthognathic surgery. J Cranio-Maxillofac Surg 17:215-18, 1989.

Kerstens HC, Tuinzing DB, Golding RP, Van der Kwast WA: Condylar atrophy and osteoarthrosis after bimaxillary surgery. Oral Surg Oral Med Oral Pathol 69: 274-80, 1990.

Kim YI, Jung YH, Cho BH, Kim JR, Kim SS, Son WS, Park SB: The assessment of the short- and long-term changes in the condylar position following sagittal split ramus osteotomy (SSRO) with rigid fixation. Oral Rehabil 37: 262-270, 2010.

Landes CA, Sterz M: Evaluation of condylar translation by sonography versus axiography in orthognathic surgery patients. J Oral Maxillofac Surg 61: 1410-7, 2003.

Laskin DM, Ryan WA, Greene CS: Incidence of temporomandibular symptoms in patients with major skeletal malocclusions: A survey of oral and maxillofacial surgery training programs. Oral Surg Oral Med Oral Pathol 61:537-41, 1986.

Leonard M: Preventing rotation of the proximal fragment in the sagittal ramus split operation. J Oral Surg 34: 942, 1976.

Link JJ, Nickerson JW: Temporomandibular joint internal derangements in an orthognathic surgery population. Int J Adult Orthod Orthognath Surg 7:161-9, 1992.

Moore KE, Gooris PJJ, Stoelinga PJ. The contributing role of condylar resorption to skeletal relapse following mandibular advancement surgery: report of five cases. J Oral Maxillofac Surg 49: 448-60, 1991.

Oster C, Katzberg RW, Tallents RH, Morris TW, Bartholomew J, Miller TL, Hayakawa K: Characterization of temporomandibular joint sounds. Oral Surg. 58: 10-16, 1984.

Renzi G, Becelli R, Di Paolo C, Iannetti G: Indications to the use of condylar repositioning devices in the surgical treatment of dental-skeletal class III. J Oral Maxillofac Surg 61: 304-9, 2003.

Rotskoff KS, Herbosa EG, Villa P: Maintenance of the condyle proximal segment position in orthognathic surgery. J Oral Maxillofac Surg 49: 2-7, 1991.

Schellhas KP, Piper MA, Omile MR: Facial skeleton remodeling due to temporomandibular joint degeneration: an imaging study of 100 patients. AJNR Am J Neuroradiol 11: 541-51, 1990.

Schellhas KP, Piper MA, Bessette RW, Wilkes CH: Mandibular retrusion, temporomandibular joint derangement, and orthognathic surgery planning. Plast Reconstr Surg 90: 218-29, 1992.

Solberg WK, Bibb CA, Nordstrom BB, Hansson TL: Malocclusion associated with temporomandibular joint changes in young adults at autopsy. Am J Orthod 89: 326-330, 1986.

Trauner R, Obwegeser H: The surgical correction of mandibular prognathism and retrognathia and consideration of genioplasty: Surgical procedures to correct mandibular prognathism and reshaping the chin. Oral Surg Oral Med Oral Pathol 10:677-689, 1957.

Trpkova B, Major P, Nebbe B, Prasad N: Craniofacial asymmetry and temporomandibular joint internal derangement in female adolescents: a posteroanterior cephalometric study. Angle Orthod 70: 81-88, 2000.

Ueki K, Degerliyurt K, Hashiba Y, Marukawa K, Nakagawa K, Yamamoto E: Horizontal changes in the condylar head after sagittal split ramus osteotomy with bent plate fixation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 106:656-61, 2008.

Ueki K, Miyazaki M, Okabe K, Mukozawa A, Marukawa K, Moroi A, Nakagawa K, Yamamoto E: Assessment of bone healing after Le Fort I osteotomy with 3-dimensional computed tomography. J Craniomaxillofac Surg 39: 237-43, 2011.

Ueki K, Nakagawa K, Maruakwa K, Takatsuka S, Yamamoto E: The relationship between temporomandibular joint and stress angulation in skeletal Class III patients. Eur J Orthod 27:501-506, 2005.

Ueki K, Nakagawa K, Takatsuka S, Shimada M, Marukawa K, Takazakura D, Yamamoto E: Temporomandibular joint morphology and disc position in skeletal class III patients. J Cranio Maxillofac Surg 28:362-368, 2000.

Westesson PL, Bifano JA, Tallents RH, Hatala MP: Increased horizontal angle of the mandibular condyle in abnormal temporomandibular joints. Oral Surg Oral Med Oral Pathol 72: 359-363, 1991.

White CS, Dolwick MF: Prevalence and variance of temporomandibular dysfunction in orthognathic surgery patients. Int J Adult Orthod Orthognath Surg 7: 7-14, 1992.

Will LA, Joondeph DR, Hohl TH, West RA. Condylar position following mandibular advancement: Its relationship to relapse. J Oral Maxillofac Surg 42:578-588, 1984.

Legends

Fig. 1. Simulation of the plate bending. The plates were bent to prevent the proximal segments from rotating internally. Note the gap between the osteotomy surfaces on the both sides.

Figure 2. Measurements of the horizontal CT image. Arrows show the horizontal condylar angle.

Fig. 3. Measurements of coronal CT image. a)Lateral joint space, b) Superior joint space, c) Medial joint space, d) Condylar angle, e) Ramus angle, f) Superior angle, g) Condylar width, h) Condylar height.

Fig. 4. Measurements of the sagittal CT image. a) shows the sagittal ramus angle. b) shows the anterior joint space, c) shows the posterior joint space..

Fig. 5. The classification of disc position in the sagittal image. a) Anterior displacement type, b) Anterior type, c) Fully-covered type, d) Posterior type.

Table 1. Measurements of CT images. SD indicates standard deviation.

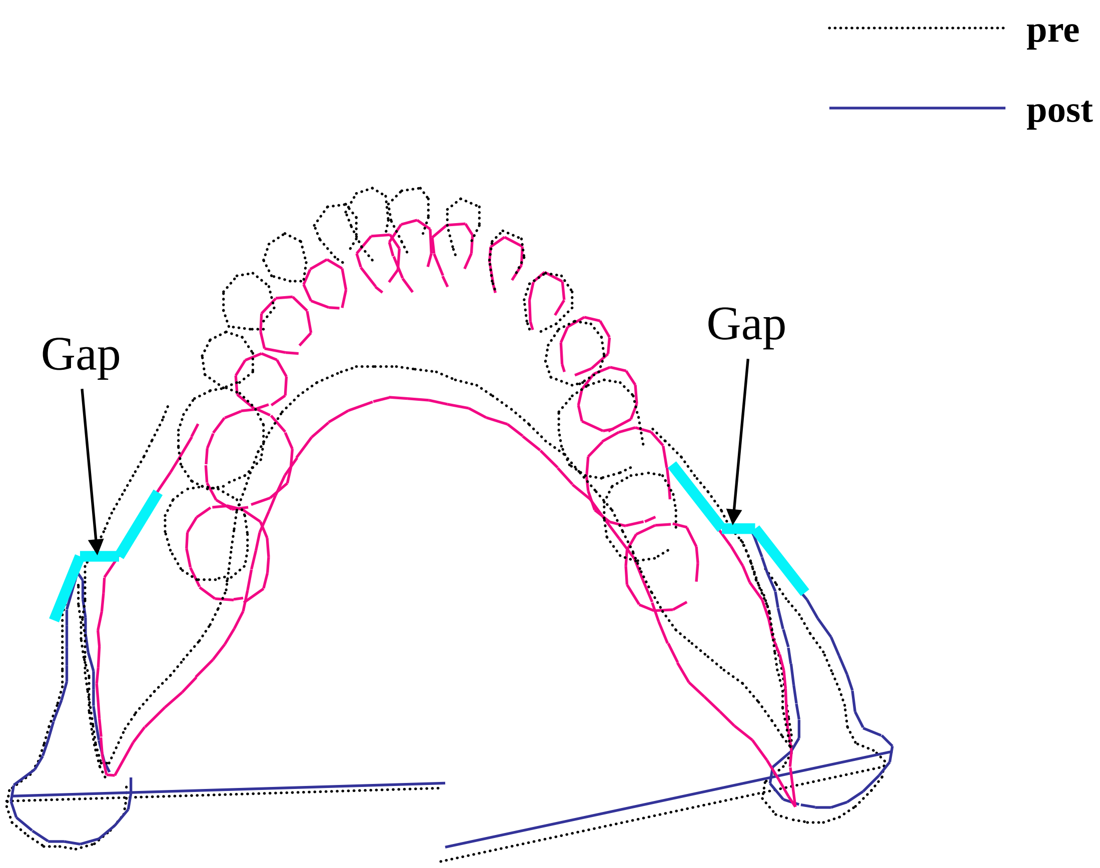

Fig. 1.

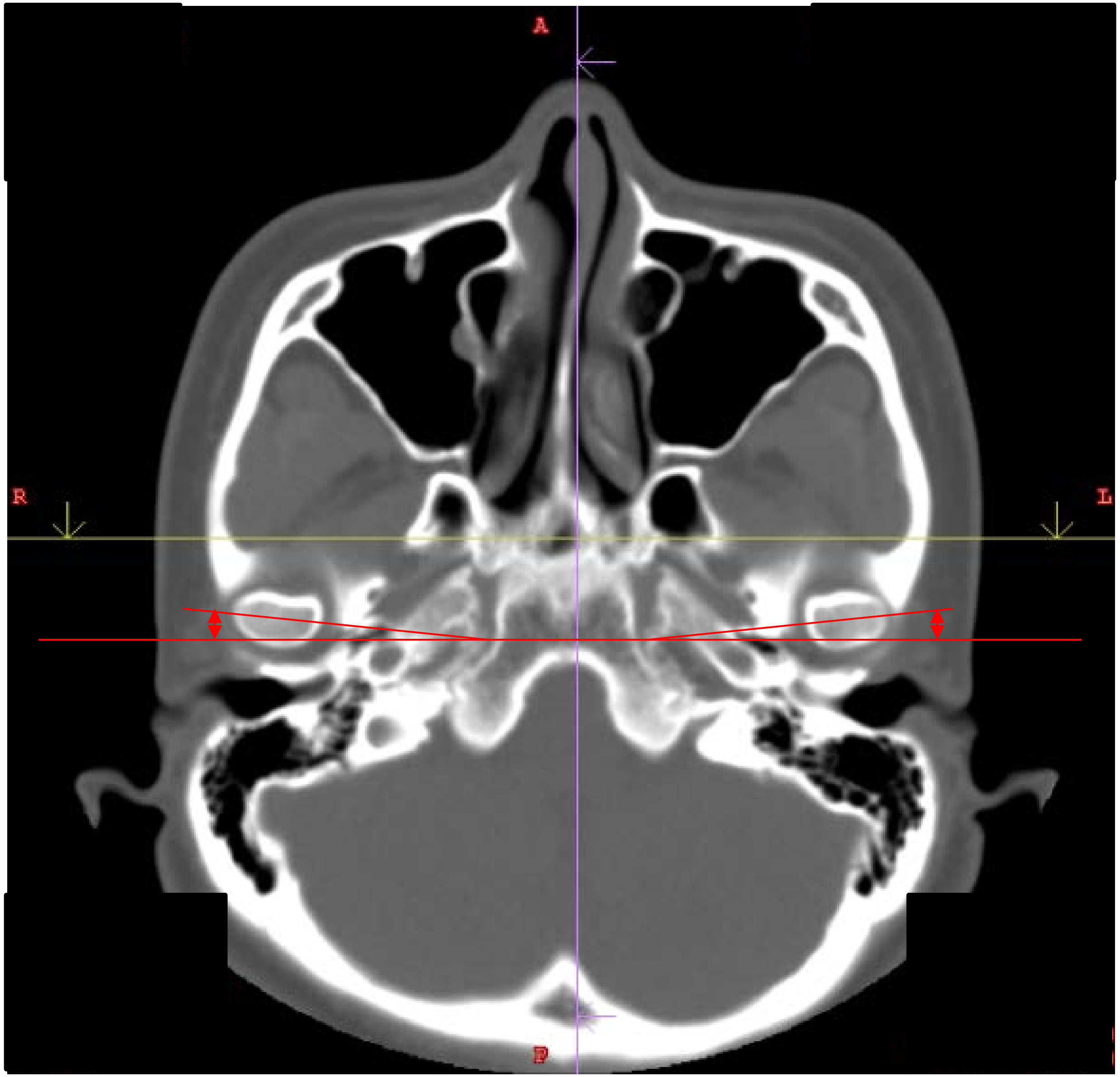

Fig. 2

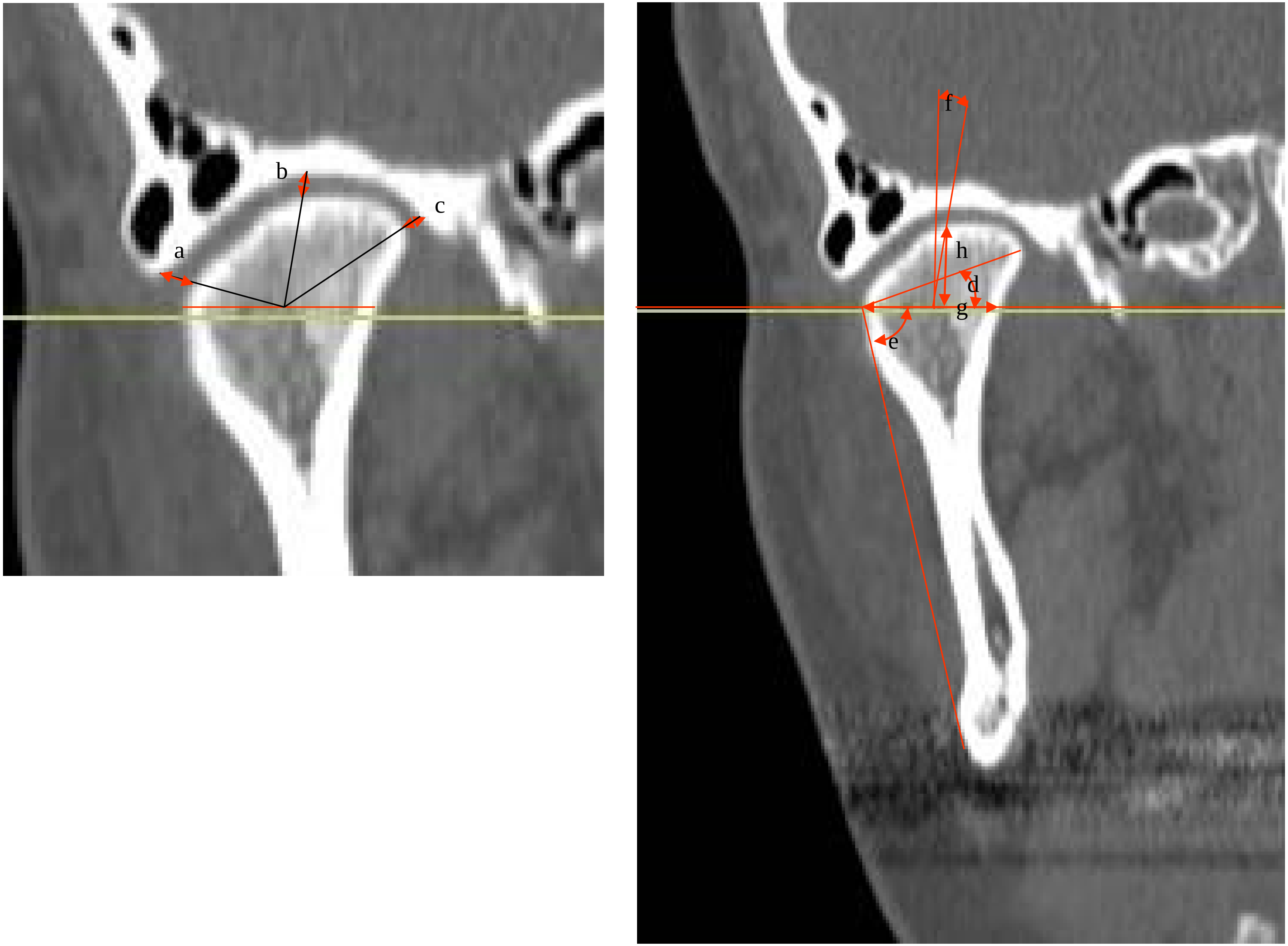

Fig. 3

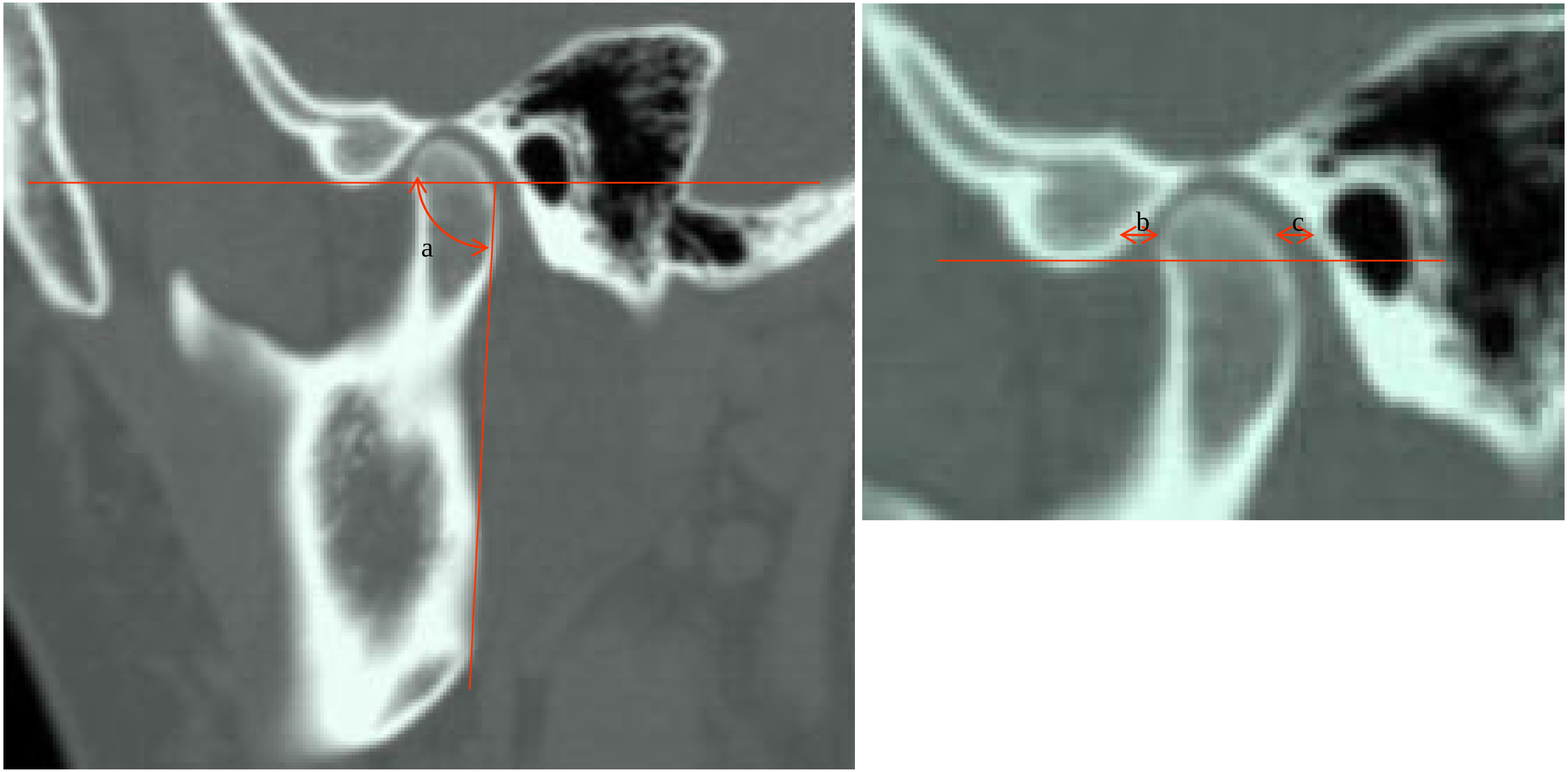

Fig. 4

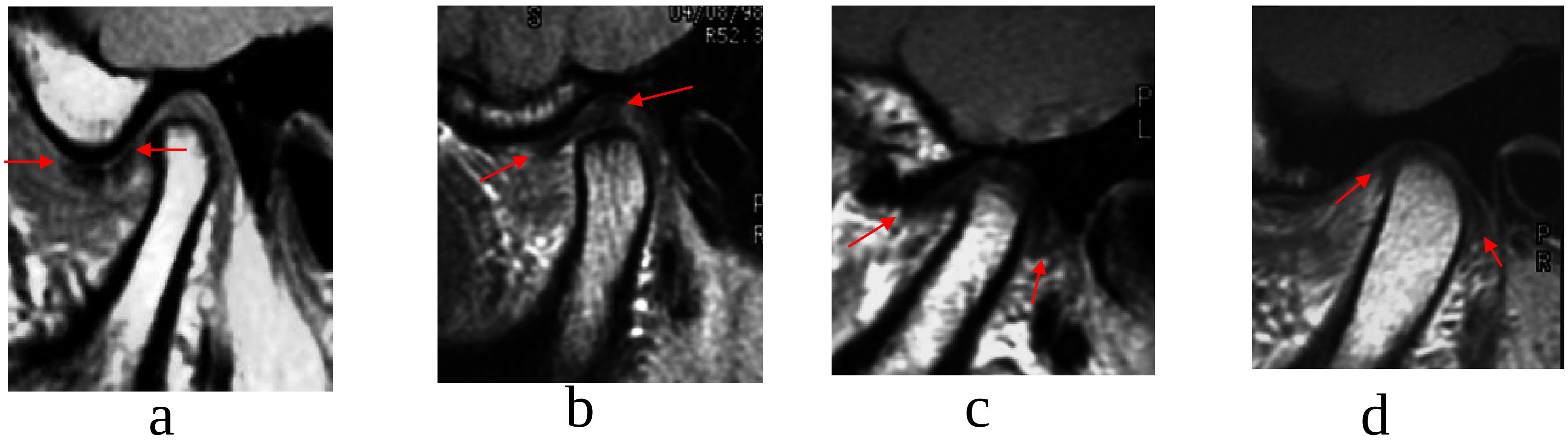

Fig. 5

				Horizontal condylar angle	Coronal condylar angle	Coronal ramus angle	Medial joint space	Lateral joint space	Sagittal ramus angle	Anterior joint space	Superior joint space	Posterior joint space
Pre-operation	Symmetry group	Deviation side	Mean	12.2	12.7	77.6	1.4	2.2	87.9	2.0	1.8	2.5
			SD	8.4	13.8	4.0	0.6	3.1	6.1	0.9	0.6	0.8
		Non-deviation side	Mean	13.0	11.9	77.8	1.5	1.5	87.5	1.9	1.8	2.5
			SD	7.2	12.4	3.4	0.6	0.7	5.9	0.8	0.6	0.9
	Asymmetry group	Deviation side	Mean	14.8	13.9	79.4	1.5	1.7	88.6	1.7	1.9	2.6
			SD	7.5	10.4	4.3	0.6	0.7	5.7	0.7	0.8	1.1
		Non-deviation side	Mean	13.4	14.5	75.9	1.6	1.6	87.9	2.0	1.8	2.4
			SD	6.6	11.5	4.2	0.7	0.7	5.7	0.7	0.7	1.0
Post-operation	Symmetry group	Deviation side	Mean	11.2	12.3	77.6	1.5	1.9	91.0	2.5	2.1	3.1
			SD	9.0	11.1	8.4	0.6	0.9	7.0	1.0	0.7	0.9
		Non-deviation side	Mean	12.7	10.8	78.6	1.4	1.7	88.6	2.6	2.1	3.1
			SD	7.1	12.2	4.0	0.7	0.7	14.6	0.8	0.6	1.0
	Asymmetry group	Deviation side	Mean	14.9	11.1	79.3	1.5	1.8	89.1	2.2	2.1	2.8
			SD	6.9	10.1	4.3	0.6	0.8	6.3	0.8	0.8	1.0
		Non-deviation side	Mean	12.9	10.8	75.1	3.4	1.9	88.9	2.4	2.0	2.7
			SD	7.3	11.3	12.0	12.2	1.2	6.5	0.8	0.7	1.0

Table 1.