Original Article

Preoperative Planning for Eccentric Rotational Acetabular Osteotomy

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Abstract

Background and Design: Eccentric rotational acetabular osteotomy (ERAO), allows for the consistent achievement of the desired displacement of the femoral head. To our knowledge, a method of preoperative planning for this procedure has not been reported. We propose two methods of preoperative planning based on the assumption that all points inside the osteotomy circle rotate θ degrees around the center of this circle when the acetabulum is rotated θ degrees around the center. The objectives of this study were to confirm the above assumption and to examine the appropriate radius of curvature for the osteotome used during ERAO.

Methods: In July 2012, ERAO was performed on four patients with acetabular dysplasia based on the surgeon's planning diagram. The horizontal and vertical distances between the preoperative and postoperative centers of the femoral head were measured on the surgeon's planning diagram, on our planning diagram obtained with the first method, and on radiographs, respectively. We also performed preoperative planning by our second method. The radius of curvature of the osteotome was then measured from our preoperative planning data.

Results: The horizontal and vertical distances on our diagrams corresponded closely to the distances on the radiographs. In contrast, the horizontal distances on the surgeon's diagrams were larger than those on the radiographs. The radius of curvature of the osteotome was 37, 32, 32, and 41 millimeters (mm) in case 1, 2, 3, and 4, respectively

Conclusion: The present study demonstrated that the horizontal distance and the vertical distance on our planning diagrams corresponded closely to the distances on the radiographs, suggesting that our assumption was verified. Our two methods of preoperative planning are both suitable for ERAO. Finally, an osteotome with a radius of curvature less than 50 mm is appropriate for ERAO.

Keywords: osteoarthritis, hip joint, rotational acetabular osteotomy, preoperative planning
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Introduction

Various surgical procedures have been reported for the treatment of hip osteoarthritis due to acetabular dysplasia. Rotational acetabular osteotomy (RAO) was first reported by Ninomiya and Tagawa in 1986[1]. This osteotomy procedure provides effective coverage of the femoral head with acetabular cartilage, and it is also possible to obtain substantial medial and distal displacement of the femoral head by using this technique. However, it is difficult to predict the distal and medial extent of femoral head translation. Hasegawa modified the procedure by making an eccentric osteotomy around the center of rotation of the femoral head (eccentric rotational acetabular osteotomy: ERAO)[2]. When this modified technique is used, it is possible to calculate or predict the extent of the femoral head translation, but Hasegawa did not describe a method for preoperative planning.

Here, we propose two methods of preoperative planning based on the assumption that all the points inside the osteotomy circle rotate θ degrees around the center of that circle when the acetabulum is rotated θ degrees around the center.

The purpose of this study was to confirm the assumption that all points inside the osteotomy circle rotate θ degrees around the center of this circle when the acetabulum is rotated θ degrees around the center, and to determine the appropriate radius of curvature of the osteotome for ERAO.

Materials and Methods

Patients

In July 2012, ERAO was performed on four patients who had acetabular dysplasia, with the procedures being done according to the surgeon's preoperative planning method. To assess the assumption, we employed the same preoperative center of the femoral head, osteotomy site, and radius of curvature of the osteotome as those planned preoperatively by the surgeon.

The horizontal distance between the preoperative and postoperative centers of the femoral head, as well as the vertical distance between the preoperative and postoperative centers of the femoral head, were measured on surgeon's planning diagram, on our planning diagram obtained with the first method, and on radiographs (Fig. 1).

For assessment of the appropriate radius of curvature of the osteotome for ERAO, we employed the same postoperative center of the femoral head as that planned preoperatively by the surgeon.

The radius of curvature of the osteotome

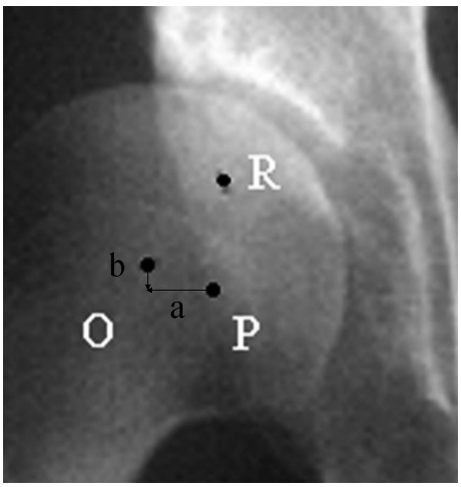

Fig. 1 Measurement of the horizontal and vertical distances

The horizontal distance (a) between the preoperative center of the femoral head (O) and the postoperative center (P) and the vertical distance (b) between the preoperative center of the femoral head (O) and the postoperative center (P) were measured on each planning diagram and radiograph.

was measured on our preoperative planning diagrams obtained with the second method.

The methods of our preoperative planning

The first method of preoperative planning is displayed in Fig. 2A, 2B and 2C.

First, a circle with the same radius of curvature as the osteotome is drawn around the central point of the osteotomy site (approximately 15 mm from the joint space) on the ilium. Then a circle with the same radius of curvature as the osteotome is drawn around the central point of the osteotomy site (near the teardrop) on the pubis. Subsequently, a circle is drawn that passes through the center of the femoral head and the lateral intersection of the previous two circles. The point obtained by rotating the center of the femoral head θ degrees around this circle is the postoperative center of the femoral head.

The second preoperative planning method is shown in Fig. 3A and 3B.

The acetabular fragment would be rotated into the intended position in which a preoperative curved area of dense bone on the weight-bearing surface of the ilium would locate horizontally. And the center of the postoperative femoral head would located to get continuity of Shenton's line.

First, an isosceles triangle is drawn for which the vertex angle is θ and the base is a line connecting the center of the preoperative femoral head with the center of the postoperative femoral head. The vertex of the triangle is located at the rotational center of the acetabulum after osteotomy. Then a circle passing through the central point of the osteotomy site on the ilium is drawn around the vertex of the triangle. The radius of this circle is the radius of curvature of the osteotome.

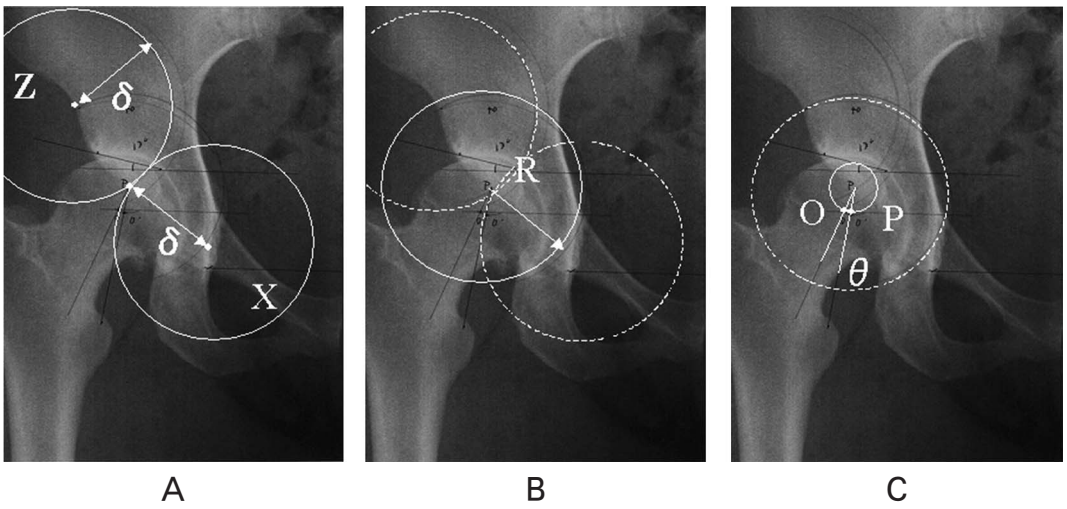

Fig. 2 First method of operative planning

A: First, draw a circle having the same radius of curvature (δ) as the osteotome around the center of the osteotomy site (Z) on the ilium. Next, draw a circle having the same radius of curvature (δ) as the osteotome around the center of osteotomy site (X) on the pubis.

B: Then draw a circle passing through the center of the femoral head at the intersection (R) of the previous two circles.

C: The point obtained by rotating the center of the femoral head (O) θ degrees on this circle is the postoperative center of the femoral head (P).

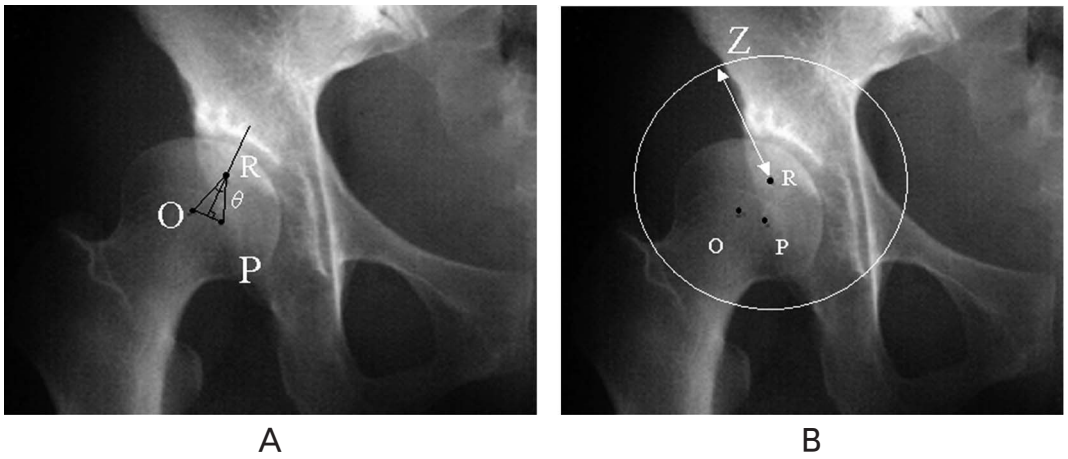

Fig. 3 Second method of operative planning

A: First, draw an isosceles triangle (ROP) for which the vertex angle is θ and the base is a line connecting the center of the preoperative femoral head (O) with the center of the postoperative femoral head (P). The vertex (R) is located at the rotational center of the osteomized acetabulum.

B: Then draw a circle around the vertex (R) that passes through the center of the osteotomy site (Z) on the ilium. The radius of this circle (RZ) is the radius of curvature of the osteotome.

Principles of the two preoperative planning methods

We need to define the following terms. The Arc AC is a preoperative curved area of dense bone on the weight-bearing surface of the ilium, which was called the "soucil" by Pauwels[3]. O is the preoperative center of the femoral head, Arc A'C' is the postoperative soucil, and P is the postoperative center of the femoral head. In addition, θ is the angle of acetabular rotation and R is the center of the osteotomy circle (Figs. 4 and 5). We assume that all points inside the osteotomy circle rotate θ degrees around R if the acetabulum is rotated θ degrees around R. The preoperative center of the femoral head (O) rotates around the center of the osteotomy circle, so triangle OPR is an isosceles triangle. Therefore, if a triangle with vertex R is drawn on the perpendicular bisector of the line OP and the vertex angle thus obtained is theta, the vertex corresponds to the center of the osteotomy circle (Fig. 5).

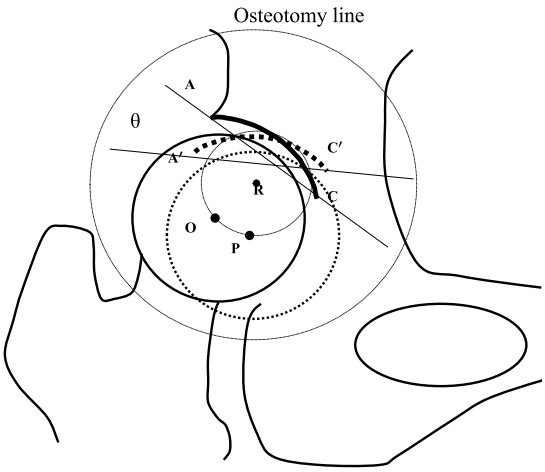

Fig. 4 Rotation of the acetabulum and femoral head

arc AC	preoperative soucil
O	preoperative center of the femoral head
arc A'C'	postoperative soucil
P	postoperative center of the femoral head
θ	angle of acetabular rotation
R	center of the osteotomy line

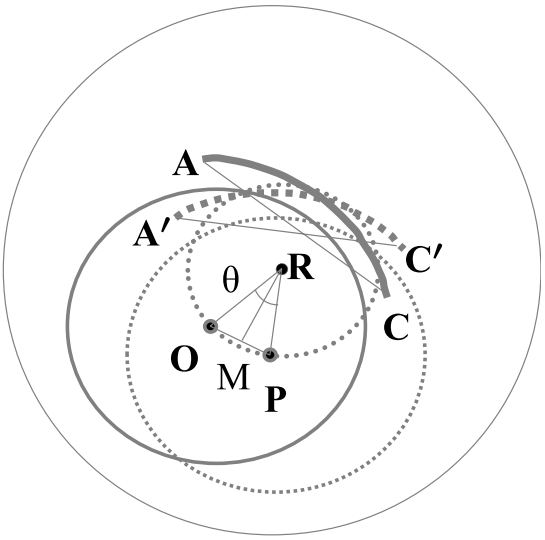

Fig. 5 Principles of preoperative planning
Assume that all the points inside the osteotomy circle rotate θ degrees around R when the acetabulum rotates θ degrees around R. The preoperative center of the femoral head (O) rotates around the center of the osteotomy circle, so the triangle ROP is an isosceles triangle. Therefore, if R is drawn on the perpendicular bisector of the line OP and is the vertex of a triangle with vertex angle θ, R corresponds to the center of the osteotomy circle.

Surgeon's preoperative planning method

The osteotomy was planned with use of drawings based on an anteroposterior radiograph of the pelvis made with the hip held in maximum abduction[2].

Results

In case 1, the horizontal distance between the preoperative center of the femoral head and the postoperative center of the femoral head was 4 mm on the surgeon's planning diagram and the vertical distance was 0 mm. The horizontal distance on our planning diagram obtained with the first method was 1 mm and the vertical distance was 1 mm, while the horizontal distance was 0 mm and the vertical distance was 1 mm on the radiograph (Fig. 6). In case 2, the horizontal distance between the preoperative and postoperative centers of the femoral head on the surgeon's diagram was 5 mm and the vertical distance was 0 mm. The horizontal distance on our diagram was 0 mm and the vertical distance was also 0 mm, while the horizontal and vertical distances on the radiograph were 1 mm and 0 mm, respectively (Fig. 7). In case 3, the horizontal distance between the preoperative and postoperative center of the femoral head was 4 mm on the surgeon's diagram and the vertical distance was 0 mm. On our diagram, both distances were 1 mm, while the horizontal distance was 1 mm and the vertical distance was 0 mm on the radiograph (Fig. 8). In case 4, the horizontal distance between the preoperative and postoperative centers of the femoral head was 3 mm on the surgeon's diagram and the vertical distance was 1 mm. The horizontal distance on our diagram was 0 mm and the vertical distance was 1 mm, while both distances were 1 mm on the radiograph (Fig. 9).

Figure 10 shows the horizontal distance and vertical distance on each planning diagram and on the radiographs. The horizontal and vertical distances on our diagrams were very close to those on the radiographs. In contrast, the horizontal distances on the surgeon's diagrams were larger than those on the radiographs.

The radius of curvature of the osteotome was 37, 32, 32, and 41mm in case 1, 2, 3, and 4, respectively (Fig. 11).

Discussion

Preoperative planning is crucial for performing ERAO correctly. We investigated two methods of preoperative planning in the present study, both of which were based on

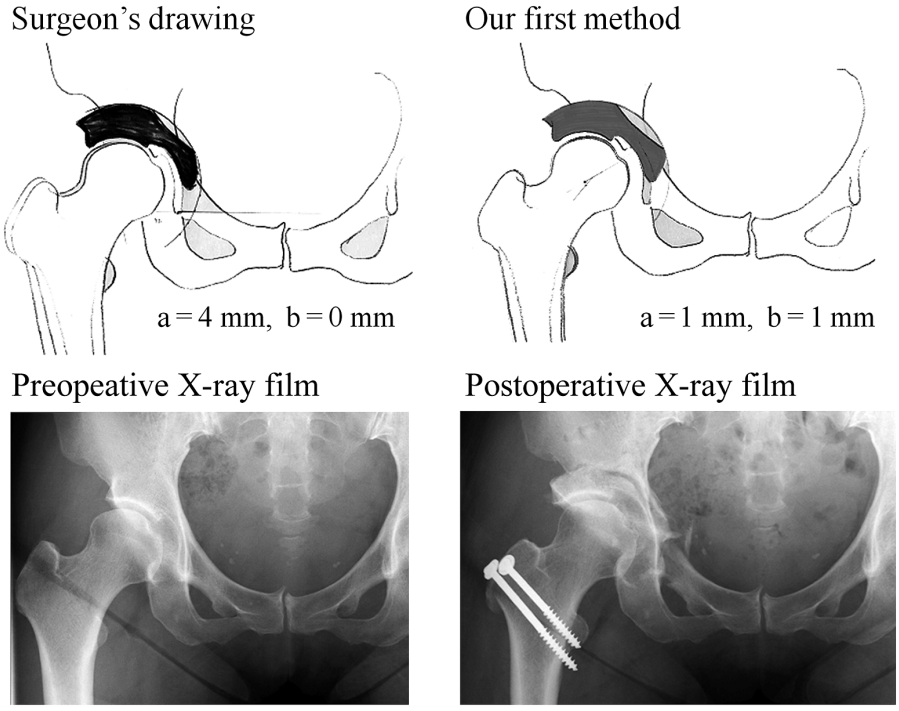

Fig. 6 Case 1

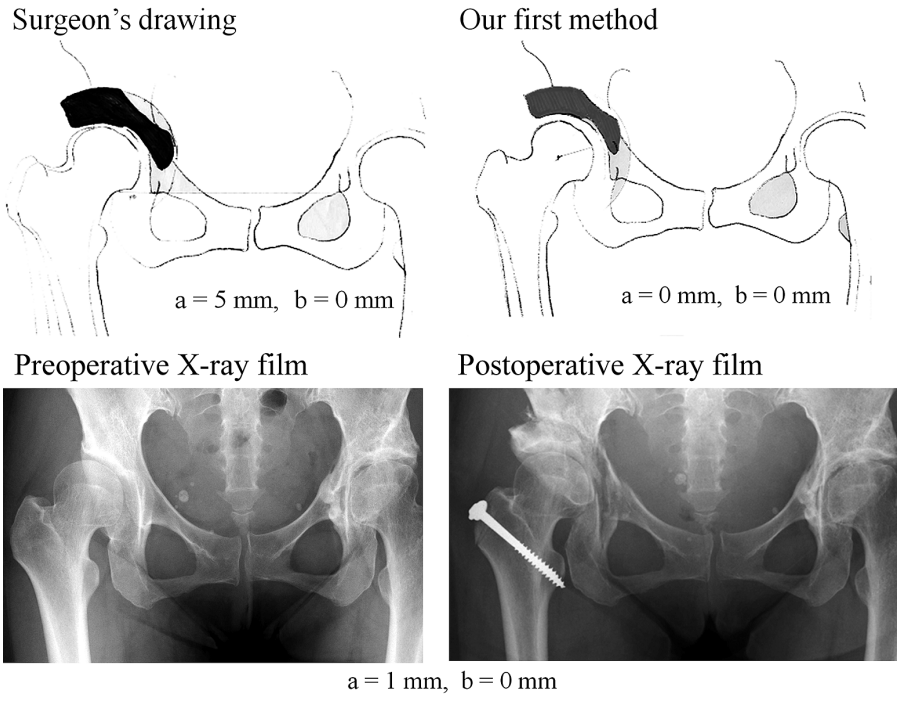

Fig. 7 Case 2

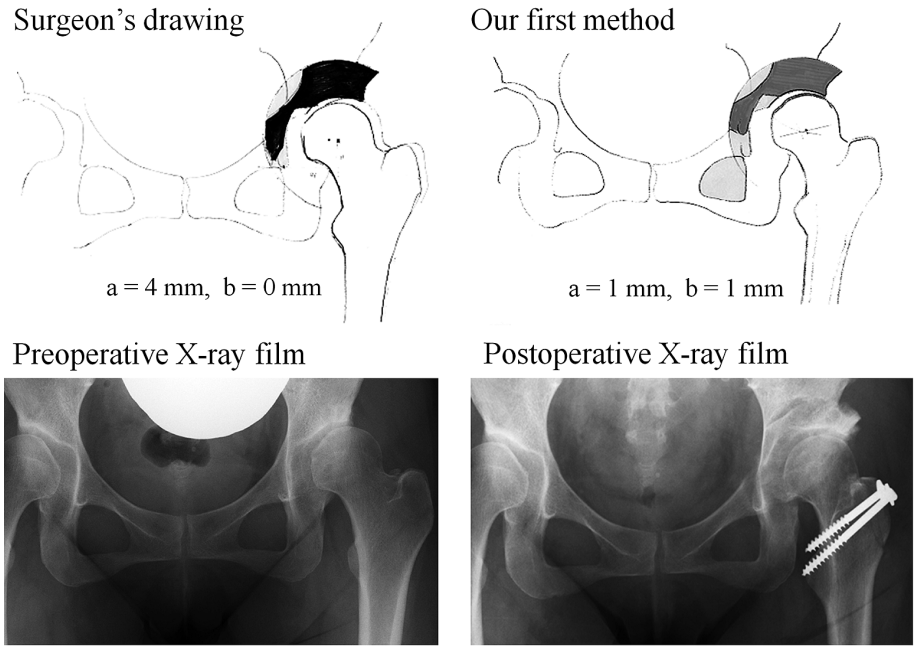

Fig. 8 Case 3

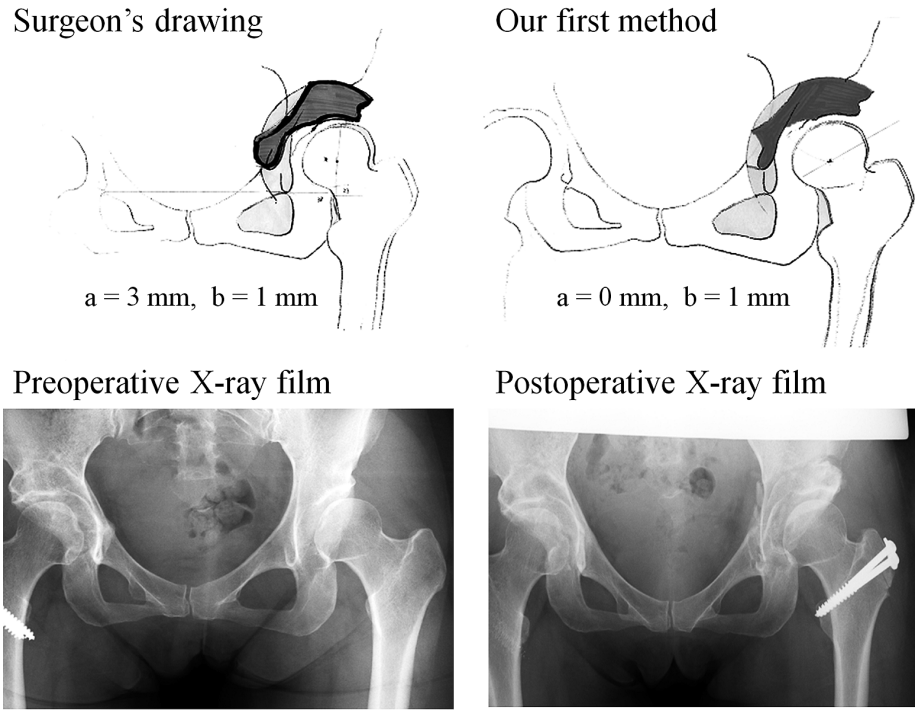

Fig. 9 Case 4

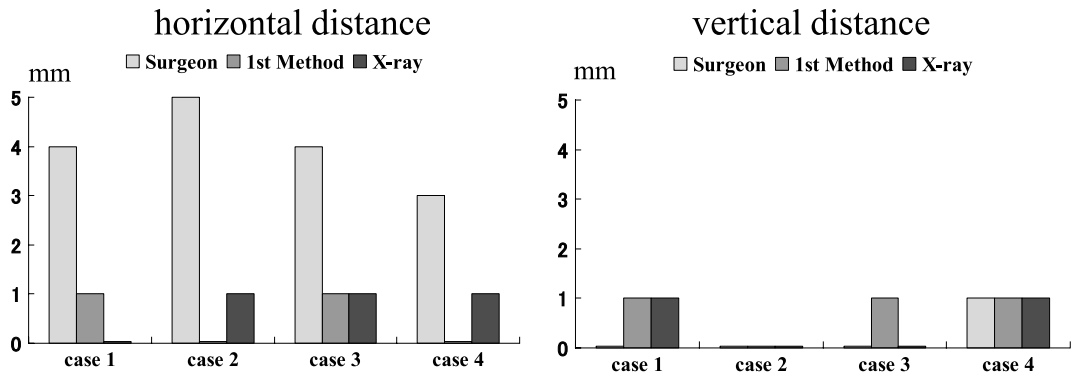

Fig. 10 The horizontal and vertical distances

The horizontal and vertical distances on our diagrams corresponded closely to the distances on the radiographs. In contrast, the horizontal distances on the surgeon's diagrams were larger than the distances on the radiographs.

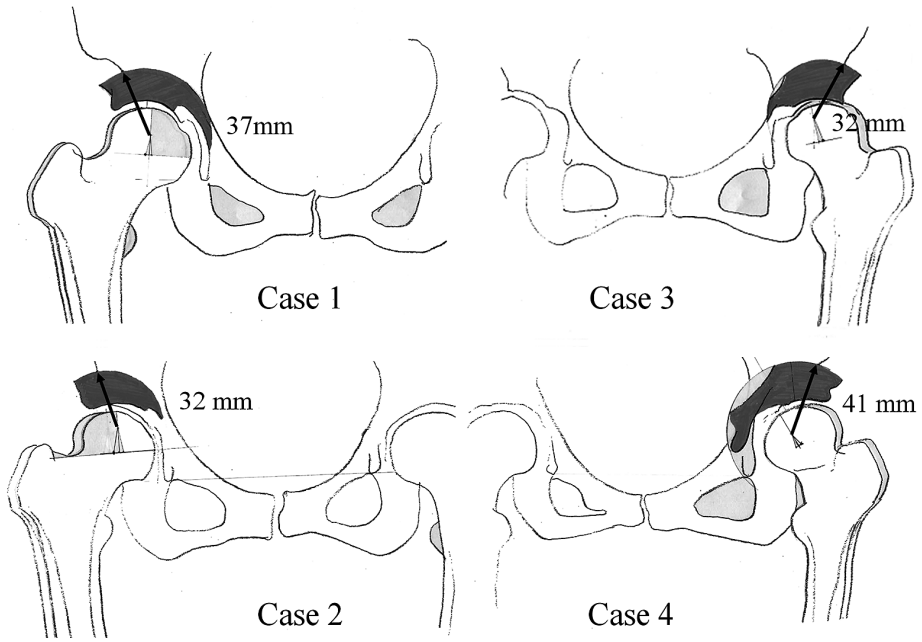

Fig. 11 Radius of curvature of the osteotome

the assumption that all the points inside the osteotomy circle rotate θ degrees around the center of this circle when the acetabulum is rotated θ degrees around the center. The present study demonstrated that the horizontal and vertical distances on our planning diagrams corresponded closely to these distances on radiographs, indicating that the above assumption was verified.

The vertical distances on the surgeon's planning diagrams also corresponded well to the distances on the radiographs, but the horizontal distances were larger than those on the radiographs. These results may have

been obtained because the vertical distance is determined by the position of the acetabulum and the thickness of the cartilage, while the horizontal distance is decided by the surgeon.

The radius of curvature of the osteotome was 37, 32, 32, and 41 mm in case 1, 2, 3, and 4, respectively. Noguchi employs osteotomes with a radius of curvature from 35 to 50 mm when performing this operation and the usual osteotome has a 40 mm radius of curvature[4]. Hasegawa uses an osteotome with a 45 mm radius of curvature, while Tagawa employs an osteotome with a 50 mm radius of curvature and excavates the acetabulum in order to obtain substantial medial displacement of the femoral head[5]. These reports suggest that an osteotome with a radius of curvature less than 50 mm is suitable for rotational acetabular osteotomy.

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