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The truth of CT-based navigation assisted curved periacetabular osteotomy

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Abstract

Curved periacetabular osteotomy (CPO) is technically demanding procedure because we have to enter the osteotomy site from inside of pelvis without direct view of hip joint. To achieve this tricky procedure without troubles such as posterior column fracture or intraarticular osteotomy, we used CT-based navigation. To investigate accuracy of osteotomy in patients who underwent CT-based navigation assisted CPO, pre- and post-operative CT images were measured with three dimensional (3D) image analyzing software. The 3D image analysis demonstrated that our osteotomies were not so accurate because each standard deviation of measurement values were not small. Our clinical data showed that 73% patients developed cartilage degeneration after CPO in postoperative X-ray films. Painful hips were observed in 26.9% and one hip was converted to total hip arthroplasty within 3 years after CPO. The first reason of these inaccuracy and unsatisfaction of our CPO was lack of consensus for true target zone of rotated acetabulum in CPO. We determined each final acetabular position by checking with intraoperative fluoroscopic 2D images. The second reason was that the current CT-based navigation could only assist osteotomy of ilium and quadrilateral surface. In addition, our navigation could not assist acetabular rotation in real time. Further improvements are required to achieve more accurate and successful CPO with computer assisted surgery.

1 Introduction

Curved periacetabular osteotomy (CPO) was developed for the treatment of hip dysplasia in 1995[1]. We can expose the osteotomy site from the inside of pelvis without damaging hip abductor muscles. However, it is quite difficult to cut the acetabulum in a spherical shape without looking at hip joint directly. Therefore, we started to use CT-based navigation to achieve accurate and safe periacetabular osteotomy since 2010. Few reports about navigation assisted periacetabular osteotomy showed postoperative three dimensional (3D) image analysis and navigation accuracy [2-5]. The objective of this study was to investigate accuracy of pelvic osteotomy in our CPO with 3D images analysis using pre- and post-operative CT images. We measured femoral head coverage, displacement of femoral head center, and the differences between plan and postoperative osteotomized spherical centers. In addition, clinical outcomes were also investigated.

2 Patients and methods

We analyzed 52 hips of 49 patients who underwent CT-based navigation assisted CPO from 2010 to 2019. The mean operative age was 38.3 years old (range: 16-58 years old) and the mean body mass index was 21.8 Kg/m^2, including 47 females and 2 males. Differences of lateral, anterior, and posterior center-edge (CE) angles and femoral head coverage rates among the preoperative, plan, and postoperative CT images were measured with 3D image analyzing software. The preoperative and postoperative CT images were superimposed by 3D-3D registration to measure displacements of the femoral head centers and the osteotomy spherical centers. Radiographic outcomes and clinical hip functions were also investigated.

3 Results

The preoperative, plan, and postoperative lateral CE angles were 10.4±11.3º, 32.0±6.4º, and 32.5±14.0º, respectively. The anterior CE angles were 31.5±20.7º, 44.3±9.6º, and 54.9±10.6º, respectively. The posterior CE angles were 96.5±21.5º, 95.0±14.6º, and 93.5±25.0º, respectively. The preoperative, plan, and postoperative femoral head coverage rates were 61.7±9.3%, 85.5±5.1%, and 88.8±8.1%, respectively. The displacements of femoral head centers were x axis=3.7±4.9 mm medial, y axis=2.3±3.1 mm anterior, and z axis=3.2±2.4 mm superior, respectively. The differences of plan and postoperative osteotomy spherical centers were x axis=-0.4±8.4 mm medial, y axis=-0.7±5.2 mm anterior, and z axis=-0.8±6.7 mm superior, respectively. Radiographic outcomes showed 73% patients developed cartilage degeneration after CPO. Painful hips were observed in 26.9% and one hip was converted to total hip arthroplasty within 3 years after CPO.

4 Discussion

The 3D morphological femoral head coverages after CPO were improved in this study. The displacements of femoral head centers demonstrated our CPO could achieve femoral head medialization. The mean values of the differences of osteotomy spherical centers between plan and postoperative CT were less than 1 mm, however, their standard deviations were over 5 mm. This indicated that our current CT-based navigation could not reproduce the planning osteotomy accurately. The clinical results showed 73% patients developed cartilage degeneration after CPO in postoperative X-ray films. Painful hips were observed in 26.9% and one hip was converted to total hip arthroplasty within 3 years after CPO. The first reason of these inaccuracy and unsatisfaction of our CPO was lack of consensus for true target zone of rotated acetabulum in CPO. We determined each final acetabular position by checking with intraoperative fluoroscopic 2D images. The second reason of this inaccuracy was that only iliac bone and quadrilateral surface could be osteotomized using our navigation. Pubic bones were cut manually, and ischial bones were cut under image control. In addition, the rotation of the osteotomized acetabular fragments could not be regulated in real time by our current navigation. In total hip arthroplasty, CT-based navigation provides real time assists during both bone reaming and cup placement which result in acceptable accuracies of implant positions [6-9]. We hope improvements of computer assisted surgery by the developers to achieve more accurate and successful CPO.

5 Conclusion

Our CT based navigation assisted CPO could not provide acceptable accuracies of both osteotomy and acetabular rotation. In addition, 26.9% of cases demonstrated painful hip and one hip was converted to total hip arthroplasty. True target zone of rotated acetabulum is still unclear and real time intraoperative control of rotated acetabulum cannot be achieved in current navigation. We need further developments of computer assisted pelvic osteotomy.

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