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Validation of Patient Specific Surgical Guide for Curved Periacetabular Osteotomy

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Abstract

In order to elucidate the accuracy of pelvis osteotomy patient specific surgical guide (PSG) setting comparing between the preoperative planning and intraoperative computed tomography (CT), and to determine the usefulness of PSG comparing between the preoperative planning and postoperative CT in curved periacetabular osteotomy (CPO), we performed experimental study using fresh cadaver samples. A total of 18 hips from 9 fresh cadaveric samples used. All hips were imaged from the whole pelvis to the femoral condyles using helical CT to design the preoperative planning and to produce PSG. PSG consisted of osteotomy guide part and rotation guide part of the bone fragments. CPO with PSG was performed in 9 hips (PSG group) while CPO without surgical guide was performed in other 9 hips (manual group). The absolute errors between the preoperative planning and PSG setting for CPO were acceptable. The absolute errors in PSG group between the preoperative planning and the surgery was significantly smaller in the flexion angle, the anteroposterior direction, and the osteotomy lines of the ilium than in manual group. The PSG for CPO is useful for the osteotomy of the pelvis and for the rotation of the acetabular bony fragment.

Introduction

Patient specific surgical guide (PSG) has been introduced as a convenient surgical instrument for osteotomy and arthroplasty [1,2]. The accuracy of PSG for pelvic osteotomy has been sporadically reported [3,4]. In order to elucidate the accuracy of pelvis osteotomy PSG setting comparing between the preoperative planning and intraoperative computed tomography (CT), and to determine the usefulness of PSG comparing between the preoperative planning and postoperative CT in curved periacetabular osteotomy (CPO), we performed experimental study using fresh cadaver samples.

Materials and Methods

A total of 18 hips from 9 fresh Caucasian cadaveric samples, including whole pelvis and bilateral lower limbs were used. Cadavers comprised 4 men and 5 women (mean age, 70 years; mean height, 167cm; mean weight, 55kg). All hips were imaged from the whole pelvis to the femoral condyles using (first-time) helical CT. The helical CT data were reconstructed at 1-mm interval and transferred to a workstation as STL format. The preoperative planning was performed as follows. The osteotomy line of the ilium and ischium was decided using the sphere which radius was 50mm while the osteotomy line of the pubis was decided using the sphere which radius was 43mm. Then, the acetabular fragment was rotated laterally to acquire more than 40° in lateral center-edge angle. PSG for CPO was designed based on the preoperative CT data using image-processing software. All PSGs were made from resins and produced by a machine (FORMIGA) using a rapid prototyping method. PSG consisted of osteotomy guide part (Fig.1a), which had four 2-mm diameter metal sphere markers for the evaluation of PSG setting accuracy on the bone surface, and rotation guide part (Fig.1b), which regulated rotation angle of the bone fragments. CPO with PSG was performed in 9 hips (PSG group) while CPO without surgical guide was performed in other 9 hips (manual group). After PSG for CPO was fixed screws on the pelvis bone surface, second-time (intraoperative) CT was imaged for validation assessment between the preoperative planning and PSG setting in 9 PSG group hips. After CPO procedure, which included osteotomy, rotational motion, and screw fixation of the acetabular fragment, third-time (postoperative) CT was imaged for validation assessment between the preoperative planning and the surgery in all 18 hips.

Results

The absolute error between the preoperative planning and PSG setting for CPO was 1.6±0.9mm for the horizontal direction, 1.8±1.5mm for the anteroposterior direction, and 2.7±2.3 mm for the vertical direction, respectively. The absolute errors between the preoperative planning and postoperative CT (PSG / manual) was 2.8±1.8° / 7.9±5.4° (p=0.03) for the flexion angle, 2.6±1.9° / 5.9±5.5° (p=0.15) for the abduction angle, and 2.5±1.3° / 3.3±1.8° (p=0.29) for the anteversion, 3.8±2.6 mm / 5.0±3.8mm (p=0.46) for the horizontal direction, 4.6 ± 2.9 mm /11.6 ± 6.8mm (p=0.02) for the anteroposterior direction, and 3.7 ± 2.7 mm /10.2 ± 10.7mm (p=0.14) for the vertical direction, respectively. There were significant differences in osteotomy lines of the ilium (p=0.03) between PSG group and manual group, while there were no significant differences in osteotomy lines of the pubis.

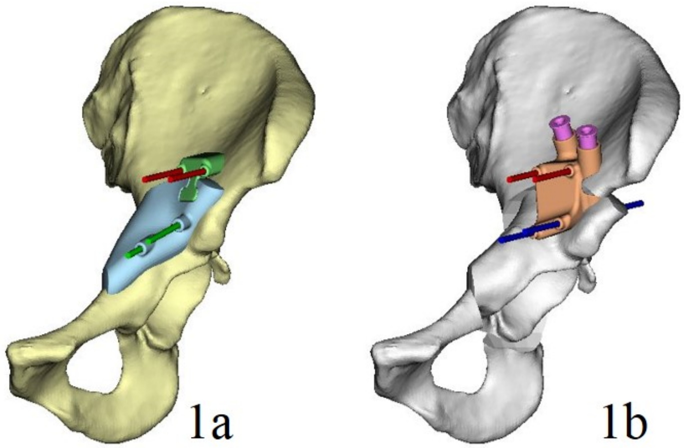

Figure 1: Fig.1a. Patient specific surgical guide for curved periacetabular osteotomy. Osteotomy guide part (PSG setting). 1b. Rotation guide part.

Discussion

The absolute errors between the preoperative planning and PSG setting for CPO were elucidated using CT data, and the absolute error was acceptable compared with the absolute errors of the PSG for another pelvis osteotomy, rotational acetabular osteotomy (RAO) [4]. CPO procedure is started from the inner surface of the pelvis [3] while RAO is performed from the outer surface of the pelvis. The absolute errors in PSG group between the preoperative planning and the surgery was significantly smaller in the flexion angle, the anteroposterior direction, and the osteotomy lines of the ilium than in manual group. In conclusion, the PSG for CPO is useful for the osteotomy of the pelvis and for the rotation of the acetabular bony fragment.

References

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