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Utility of Hybrid Templating by Enlargement Rate of Hip Bone in Total Hip Arthroscopy

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Abstract

Background/Objectives: This study is to investigate the enlargement rate of hip AP X-ray image to lower the errors occurred in the process of attaching calibration marker or calibration ball on the skin in case of hip AP X-ray test that is performed to measure the size of hip bone prior to the surgery in the patients who will undergo total hip arthroscopy, and to investigate the method of hybrid templating which can be applied to PACS with transparent acetate template used for conventional acetate templating in the hospitals where no program of digital templating is available.

Methods/Statistical analysis: To calculate the enlargement rate by height using X-ray device and to investigate the real height of hip joint, the height was measured using HIP 3D Sagittal Images of MRI. To compare the size of hip implant before and after the surgery, the sizes of acetabular cup, femur stem, and femur neck predicted by pre-surgery templating were compared with the real sizes of implants which were used.

Findings: The height of acrylic phantom was 1 cm, and enlargement rate was approximately 1% per cm. In HIP 3D Sagittal Images of MRI, mean height of hip joint were 99.23 mm and 98.38 mm in males and females, respectively. The height of hip joint from the slimmest subject in MRI was 80.30 mm while that from the most obese subject was 117.10 mm. With respect to the enlargement rate by height of hip joint, that from the slimmest subject was about 115% and that from the most obese subject was about 119%, demonstrating about 4% difference.

Improvements/Applications: To lower the errors of markers occurred in hip AP X-ray test that is performed prior to the surgery in the patients who will undergo total hip arthroscopy, the enlargement rate of hip AP X-ray image was investigated. Also, the utility of hybrid templating method applied to PACS with transparent acetate template was confirmed in the hospitals where digital templating was not available.

Keywords: total hip arthroplasty, conventional acetate templating, digital templating, Hip AP X-ray, enlargement rate

1. Introduction

Total hip arthroplasty, which is to make movable joint without pain if the joint is devastated to cause pain and limitation of the joint movement resulting in the inconveniences in the daily life, is a surgical procedure to change the devastated joint into the artificial implant [1]. The success of total hip arthroplasty relies on the pre-surgery templating. In total hip arthroplasty, hip implant made of stainless alloys or cobalt-chromium alloy and acetabular cup made of polyethylene should be prepared to meet the size of patient's hip bone [2]. Hence, hip AP X-ray test is performed to measure the sizes of hip implant and acetabular cup. To find out the real size of hip bone, its enlargement rate should be found in the images. To do so, hip AP X-ray test is performed attaching with calibration marker or calibration ball on the skin of the patient at the height of greater trochanter. However, the positions of calibration marker and calibration ball at the height of greater trochanter may be changed during internal rotation of hip joint, and in some cases, calibration marker cannot be located parallelly depending on the individual differences of examiners. Errors can be occurred in the measurements of hip bone by these multiple variables [3-5].

This study is to investigate the enlargement rate of hip AP X-ray image to lower the errors occurred in the process of attaching calibration marker or calibration ball on the skin in case of hip AP X-ray test that is performed to measure the size of hip bone before surgery in the patients who will undergo total hip arthroscopy, and to investigate hybrid templating method which can be applied to PACS with transparent acetate template used for conventional acetate templating in the hospitals where no program of digital templating is available.

2. Materials and Methods

2.1 Measurements in X-ray

Siemens YSIO max X-ray device was used. Roll board (1 cm) was laid on the table and the different heights were made

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using 20 sheets of 1 cm acrylic phantoms. The distance from tube to detector was 115 cm, and the scanned 14*17-inch images were transmitted to Picture Archiving and Communication System (PACS) maintaining the original copies. As seen in Figure 2, a lead was placed in the center of detector surface under the table and Coin A was placed beside that. On the table, roll board (1 cm) was laid and the different heights were made starting from 5 up to 20 sheets of acrylic phantoms. Coin B was placed on the acrylic phantoms and the images were captured not to be overlapped with the coin under the table. 16 times of image capturing were performed with enlargement of coins, and enlargement rates were calculated by the different heights considering the real size of coin with 26.50 mm as 100% (Table 1).

Table 1. Sizes and enlargement rate of coins by heights in X-ray

Height (cm)	Size of Coin A (mm)	Size of Coin B (mm)	Enlargement rate (%)
0	26.50	26.50	100.00
5	26.50	29.56	111.55
6	26.50	30.01	113.25
7	26.50	30.14	113.74
8	26.50	30.58	115.40
9	26.50	30.80	116.23
10	26.50	31.09	117.32
11	26.50	31.41	118.53
12	26.50	31.65	119.43
13	26.50	32.21	121.55
14	26.50	32.37	122.15
15	26.50	33.01	124.57

*** Coin A: coin on the detector, Coin B: coin on the acrylic phantom**

2.2 Measurements in MRI

Since X-ray test is performed for hip joint in the supine posture, the real height of hip joint was measured in MRI with the same posture. To find out the real height of hip joint, HIP 3D Sagittal Images were used in MRI. In HIP 3D Sagittal Images, the heights from skin to the center of femur head were measured (Figure 1). A total of 40 subjects were measured, including 20 males and 20 females, and their mean ages were 42 and 41 years old for males and females, respectively.

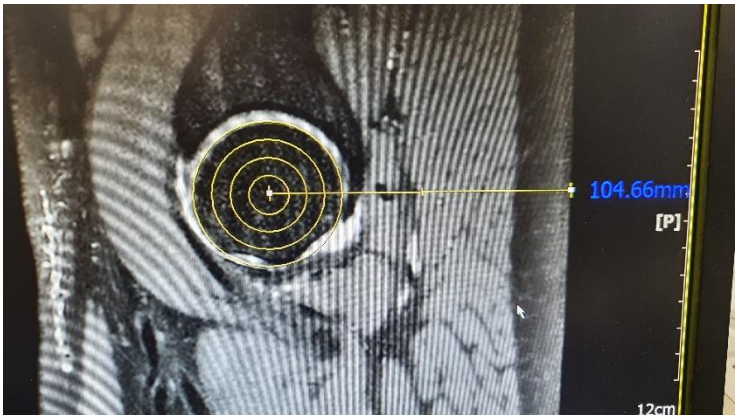

Figure 1. Measurement of hip joint height in HIP 3D Sagittal images of MRI

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2.3 Comparisons of size of hip implants pre- and post-surgery

To measure the sizes of artificial implants before surgery, the enlargement rates of hip joint were investigated in 6 patients. First, the height to greater trochanter was measured using ruler to understand the height of patient's hip joints. Enlargement rate at the measured height was applied to PACS and the sizes of acetabular cup, femur stem, and femur neck were predicted using transparent acetate template which was used in conventional acetate templating. The predicted sizes of implants were compared with the real sizes of implants which were used in the surgery (Table 2).

Table 2. Comparisons of predicted sizes of hip implants prior to surgery with their real sizes

Implant	No error	±1mm error	±2mm error
femur stem size	3	3	0
femur neck size	4	2	0
acetabular cup size	2	3	1

3. Results

In the test using X-ray device, the size of Coin A was measured as 26.50mm which was the same size of original coin. Since the image capturing of Coin A was performed on the detector, it was not affected by acrylic phantom. However, the sizes of Coin B were measured to be larger as the heights of acrylic phantoms were raised and it was shown as 31.09 mm at about 10 cm which is a mean height of hip joints in males and females measured by MRI, demonstrating 117.32% of enlargement rate from the original size of coin. The height of acrylic phantom was 1 cm, and its enlargement rate was 1% per cm in the images (Table 1). To find out the real height of hip joint, the height from skin to the center of femur head was measured in HIP 3D Sagittal Images of MRI. Mean heights of hip joints were 99.23 mm and 98.38 mm in males and females, respectively. Approximately 1 mm difference was shown in mean height of hip joint between males and females, which implicated somewhat lower height in females than males. The height of hip joint from the slimmest subject measured in MRI was 80.30 mm while that from the most obese subject was 117.10 mm(Figure 1). Reviewing the enlargement rates of hip joint height in two extreme subjects, that from the slimmest subject was about 115% and that from the most obese subject was about 119%. About 4% difference was noted in enlargement rates by the height of hip joint. In comparisons of sizes of hip implants pre- and post-surgery, 3 cases showed no errors, 3 cases showed ±1mm errors, and no case showed ±2mm errors in femur stem. 4 cases showed no errors, 2 cases showed ±1mm errors, and no case showed ±2mm errors in femur neck. 2 cases showed no errors, 3 cases showed ±1mm errors, and 1 case showed ±2mm error in acetabular cup (Table 2).

4. Discussion

In the tests using X-ray device, the enlargement rates were increased approximately by 1% as the patient's height was increased by 1 cm. In HIP 3D Sagittal Images of MRI, mean height of hip joint were 99.23 mm and 98.38 mm in males and females, respectively. In addition, the height of hip joint from the slimmest subject in MRI was 80.30 mm while that from the most obese subject was 117.10 mm, demonstrating about 4% difference upon applications of enlargement rates from X-ray tests. Using these results, the sizes were predicted by hybrid templating on hip implant before surgery and they were compared with the real sizes of implants used in the surgery. There were cases without errors and with ±1 mm errors in femur stem and femur neck. In acetabular cup, there were cases without errors up to ±2 mm errors. Yet, they were more stable than the errors occurred during the course of attaching calibration marker and calibration ball on the skin in hip AP X-ray test that is performed to measure the size of hip bone before surgery in the patients who will undergo total hip replacement arthroplasty. In hip AP X-ray test, the process to attach calibration marker and calibration ball may implicate the errors and different methods by individuals. The method may be less influenced by the subjective decisions or behaviors of the examiners who attach calibration marker or calibration ball.

The recent radiology replaced the images from past films into digitals. With the introduction of picture archiving communication system (PACS), conventional acetate templating performed in the past films has been decreased gradually and many digital programs have been developed and used [6-8]. However, the hospitals where the software for digital templating for total hip arthroscopy is not available apply hybrid templating method with conventional acetate templating in PACS. There was a report on the utility of digital templating upon comparisons of conventional acetate templating with digital templating for preoperative plans of total hip arthroscopy [9]. Also, another utility study was reported on the hybrid templating using conventional acetate templating in PACS which could be used in the hospitals without digital templating programs [2]. 6.8% of templating errors was reported by the position of calibration ball in the process of pre-surgery templating for total hip arthroscopy [10]. In a study to measure the sizes using conventional acetate templating, 42.2% that measured the sizes of acetabular cup and 68.8% that measured the sizes of femur stem before surgery were reported to be completely the same with the real sizes of

implants [3]. Also, a study reported that the tension was increased up to 6 times when femur stem with one size bigger was implanted [11]. Likewise, a variety of errors can be occurred in the process of templating before surgery and they may be implicated to the post-operative burdens of patients like bigger tension.

In terms of study limitations, more accurate and reliable data could be generated upon comparisons of hip implant sizes before and after surgery if more patients were involved. Further studies are required to conduct hybrid templating applying enlargement rates by height with more patients so as to compare with digital templating.

5. Conclusion

To lower the errors of markers occurred in hip AP X-ray test that is performed prior to the surgery in the patients who will undergo total hip arthroscopy, the enlargement rate of hip AP X-ray image was investigated. Also, the utility of hybrid templating method applied to PACS with transparent acetate template was confirmed in the hospitals where digital templating was not available. The hybrid templating method may be less influenced by the subjective decisions or behaviors of the examiners who attach calibration marker or calibration ball.

5. Acknowledgment

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