A Cadaver Anatomical Study of Using the Acetabular Anterior and Posterior Notches and the Acetabular Branch of Obturator Upper Edge to Locate the Acetabular Center

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Abstract

Background: Restoring rotation center play a vital role in total hip arthroplasty (THA), however, the method is still unclear and controversial. This study was designed to explore the method of locating the acetabular center by using anterior and posterior acetabular notches and the acetabular branch of obturator upper edge as the anatomical markers.

Methods: 20 normal adult dry pelvic specimens (40 hips) were selected to reveal the margin of acetabulum, anterior and posterior notches, the acetabular branch of obturator upper edge and Harris fossa. The rotation center, the acetabular center, the MAC (the distance between the midpoint of acetabular anterior and posterior notches line and acetabular center) and the AO1 (the distance between the midpoint of the acetabular branch of obturator upper edge and acetabular center) were measured respectively. The correlations between MAC, AO1 and the sum of vertical diameter and horizontal diameter of acetabular opening plane (SVH) were analyzed and compared respectively.

Results: The results indicated that it has a certain positive linear correlation between the SVH and MAC, AO1 by observing the changing trends of scatter diagrams. Use the SPSS software furtherly to calculate the Pearson coefficient $R = 0.592, 0.615$.

Conclusion: The acetabular anterior and posterior notches and the acetabular branch of obturator upper edge can be used to locate the acetabular center in THA. During the operation, the acetabular branch of obturator upper edge can be applied to locate the acetabular center quickly and accurately.

Keywords: Hip; Arthroplasty; Rotation Center; Acetabular Center

Abbreviations

THA: Total Hip Replacement; MAC: The distance between the midpoint of acetabular anterior and posterior notches line and acetabular center; AO1: The distance between the midpoint of the acetabular branch of obturator upper edge and acetabular center; SVH: The sum of vertical diameter and horizontal diameter of acetabular opening plane; ACL: Acetabular Center Locator

Introduction

There has been an increasing concerns toward restoring the rotation center in total hip replacement (THA). The restoration of rotation center play an important role in affecting postoperative outcomes, which may lead to increase the risk of dislocation, wear, loosening,
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Impingement and other complications [1-5]. Therefore, it is of great significance to restore the rotation center in total hip replacement. Our previous study [6] showed that the acetabular center could be located by the anterior and posterior acetabular notches of Harris fossa as the anatomical marks in THA. However, we found that the anatomical marks of the anterior and posterior acetabular notches were unclear or disappeared in some cases, such as developmental dysplasia of the hip with end stage osteoarthritis, fusion hip, hip revision. Compared with the anterior and posterior acetabular notches, the acetabular branch of obturator upper edge is more constant and easier to be found in THA. This study compared the efficacy of two anatomical marks, that were the anterior and posterior acetabular notches and the acetabular branch of obturator upper edge, to locate the acetabular center and discussed whether the acetabular center could be located by the acetabular branch of obturator upper edge, so as to provide anatomical evidence for installing acetabular prosthesis and restoring the hip rotation center more rapidly and accurately in THA.

Materials and Methods

A total of 20 dry pelvis specimens from normal adults, excluding trauma, dysplasia, tumor and other hip diseases, were selected in the study (All the specimens were provided by the Department of anatomy, Bengbu Medical College, China).

Instruments and tools

Measuring instrument: Acetabular center locator (ACL) (Measurement precision: 0.01 mm, invented by the First Affiliated Hospital of Bengbu Medical College and Trauson Medical Equipment Co., Ltd.), Vernier caliper (Measurement precision: 0.02 mm; Length: 0 - 150 mm, Haerbin Measuring and cutting Refco Group Ltd), Multi metal protractor, Combination square and Digital camera (Sony Corp).

Methods

A total of 20 normal adult pelvis were collected from the experimental specimens, the specimen's pelvics were sorted and labeled with Specimen 1 to Specimen 20.

Determination of the maximum vertical diameter and horizontal diameter of the acetabular opening plane

The maximum vertical diameter of the acetabular opening plane was determined by Martin's and Lu ’s method [7]. Generally, the maximum diameter was defined as the upper and lower diameter of the acetabular opening plane. The maximum vertical diameter of the acetabular opening plane was marked on the acetabular margin. The top point was B point which was near proximal acetabular dome. The bottom point was D point which was near distal acetabular notches (Figure 1). Vernier caliper was used to measure the length of BD line and the results were subsequently recorded (Figure 2). The maximum horizontal diameter of the acetabular opening plane was determined by the maximum vertical diameter. The intersection points of perpendicular bisector of the maximum vertical diameter to the acetabular margin are E point and F point respectively (anterior edge: E point; posterior edge: F point). The EF line was the maximum horizontal diameter of the acetabular opening plane (Figure 3). Vernier caliper was used to measure the length of EF line and the results were subsequently recorded (Figure 4).

Figure 1: BD line: The maximum vertical diameter of the acetabular opening plane.

Figure 2: Measure the length of BD line.

Figure 3: EF line: The maximum horizontal diameter of the acetabular opening plane.

Figure 4: Measure the length of EF line.

Determination of the acetabular center (O1 point)

The method used in this experiment to determine the acetabular center referred to Zhou’s [8], Shao’s [9] and Xi’s method [10]. The maximum vertical diameter BD line and the maximum horizontal diameter EF line of the acetabular opening plane were initially determined. The intersection point of BD line and EF line was rotation center O point (Figure 5). The rotation center O point to the acetabular surface vertically, the intersection point is the acetabular center O1 point (Figure 6).

The concrete operational processes: The multi-metal protractor and combination square ruler were used to determine the maximum vertical and horizontal diameter of the acetabular opening plane. 2.0 mm Kirschner wires was used to mark the intersection points of the maximum vertical and horizontal diameter to the acetabular margins. 2 nickel plated needles were fixed on the above four intersection points of B, D, E and F. The mousse suture line was used to connect B point and D point, E point and F point respectively. The intersection point of BD line and EF line was the hip rotation center (O point). 2.0 mm Kirschner wire was used to point to the acetabular surface from O point vertically. The point of Kirschner wire is the acetabular center O1 point.
Measurement of MAC, AO1 using the vernier caliper and the acetabular center locator

The acetabular center locator was used to measure the distance between the midpoint of acetabular anterior and posterior notches line and the acetabular center (MAC) and the results were subsequently recorded (Figure 6). Using the right-angle measuring device to make perpendicular line from the anterior and posterior acetabular notches to the obturator upper edge respectively. The intersection points of the obturator upper edge were G point and H point (near anterior edge: H point; near posterior edge: G point). The GH was called the acetabular branch of the obturator upper edge and the midpoint of GH line is A point (Figure 10). The maximum vertical, horizontal diameter of acetabular opening plane and the distance between the midpoint of the acetabular branch of the obturator upper edge and the acetabular center (AO1 line) were measured by the vernier caliper (Figure 2, 4 and 9). All of the above measured data retained two decimal points.

**Figure 7:** A point: the midpoint of the acetabular branch of the obturator upper edge.

**Figure 8:** AO1: The distance between the midpoint of the acetabular branch at the upper edge of the obturator and the acetabular center.
Figure 9: AO1 distance was measured by the vernier caliper.

Figure 10: GH: the acetabular branch of the obturator upper edge.

Figure 11: Scatter plot of AO1 and SVH.
Statistical analysis

SPSS software for Windows (version 20.0; SPSS, Chicago, IL) was used to calculate the Pearson correlation coefficient between AO1, MAC and SVH respectively.

Results

The Pearson correlation coefficient of AO1 and SVH was 0.615. The Pearson correlation coefficient of MAC and SVH was 0.592. The correlation coefficient of AO1 and SVH is higher than that of MAC and SVH.

Discussion

Accurate restoration of the hip rotation center is considered to facilitate to recover hip joint biomechanics and maintain the mechanical balance and stress distribution of artificial hip joint [11,12], which will prolong the survivorship of the prosthesis. The hip rotation center is the center of the femoral head or the geometric center of the hip joint. The rotation center of the hip joint in normal adults should be overlapped between the geometric center of the acetabular hemisphere and the center of the femoral head. The study of acetabular morphology usually regards the anatomical morphology of acetabular in normal adults as a hemisphere. Although Thompson [13] found that the acetabular morphology of young people was quite different from the standard sphere, the difference became smaller with the increasing of age, and the acetabular fossa with cartilage layer was closer to the standard hemisphere. The study of Greenw ALD, Gu [14], AS [15] and Eckstein F [16] showed that normal adult acetabular morphology was not a standard hemisphere, but the rotation axis of the acetabulum was usually parallel to the coronal plane of the human body. The short axis corresponds to the anteroposterior diameter of the acetabular opening plane and the long axis corresponds to the upper and lower diameters of the acetabular opening plane. The maximum diameter was defined as the upper and lower diameter of the acetabular opening plane. The maximum vertical diameter of the acetabular opening plane was marked on the acetabular margin. The top point was B point which was near proximal acetabular dome. The bottom point was D point which was near distal acetabular notches. Xu., et al. [17] also obtained similar research results. Zhou [8] considered that the intersection of the maximum vertical diameter and the horizontal diameter of acetabular opening plane was the point of hip rotation center, the acetabular center was determined by making the vertical line to the acetabular surface through the hip rotation center. Shao [9] and Xi [10] used the intersection method of longitudinal two equal line and transverse two equal line to determine the acetabular center, which provided a novel way for surgeons to determine the acetabular center during operation.

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At present, the methods of locating the rotation center of the hip before THA include template method, concentric circle method and Ranawat method [18]. However, the rotation center of the hip is a three-dimensional concept, these methods are based on the two-dimensional measurement of pelvic X-ray, therefore, the guiding value of all this method in THA are greatly limited. Zhang and Zhou [6] pointed out that the acetabular center was located at 25 ~ 31 mm (mean 28 mm, depended on the size of the acetabulum) above the perpendicular bisector of acetabular anterior and posterior notch line after the Harris fossa was recovered and the hip rotation center could be accurately restored by locating acetabular center with Harris fossa and acetabular notch as the marks. However, in some special cases, such as DDH with end stage osteoarthritis, fusion hip, hip revision, the anatomical marks of the anterior and posterior acetabular notches were unclear or disappeared, it is difficult to use the anatomical mark of anterior and posterior acetabular notches to locate the acetabular center. Compared with the anterior and posterior acetabular notches, the acetabular branch of the obturator upper edge always exists and can be quickly identified during the operation.

The study found that AO1 increased with SVH. The scatter plot diagram of AO1 and SVH indicated that there was an obvious similar trend of changing between SVH and AO1. The correlation coefficient of AO1 and SVH is higher, compared with that of AO1 and SVH. It is suggested that the midpoint of the acetabular branch of obturator upper edge (A point) could be used to locate the acetabular center (O1). The study found that the average distance between the acetabular branch of the obturator upper edge (A point) and the acetabular center (O1 point) is 33 mm. The ratio of AO1 with SVH was about 0.27.

In clinical practice, the maximum vertical and horizontal diameter of the acetabular opening plane and the distance between the midpoint of the acetabular branch of obturator upper edge and the acetabular center can be measured exactly by three-dimensional CT reconstruction of acetabulum before operation. Hence, The acetabular center can be located without the help of special tools during the operation and subsequently the acetabular prosthesis can be installed and the hip rotation center (COR) can be restored accurately.

Limitation of the Study

Our study had several limitations. This study was designed to assess the dry acetabular specimens of normal human cadavers, and the number of samples was relatively small at the same time. The corresponding relationship between the different acetabular, acetabular cup size and AO1, the normal value and variation range of AO1 needed to be further explored and studied in order to facilitate the preoperative design before the hip arthroplasty and accurate reconstruction of rotation center during the hip arthroplasty.

Conclusion

In total hip arthroplasty, the acetabular anterior and posterior notches and the acetabular branch of the obturator upper edge can be used to locate the acetabular center. During the operation, the acetabular branch of the obturator upper edge can be applied to locate the acetabular center quickly and accurately, which provides a new method for restoring the hip rotation center and installing the acetabular prosthesis accurately.

Authors’ Contributions

All authors read and approved the final manuscript.

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Availability of Data and Materials

All data generated or analyzed during this study are included in this published article.

Ethics Approval and Consent to Participate

Not applicable.

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Consent for Publication
Not applicable.

Competing Interests
The authors declare that they have no competing interests.

Authors Contribution
Haibei Hu and Heng Zhang both authors have the same contributions to the article

Bibliography


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