Original Article

# Acetabular roof arc angles and anatomic biomechanical superior acetabular weight bearing area

*Thossart Harnroongroj, Montri Wattanakaewsripetch, Narumol Sudjai, Thos Harnroongroj*

## Abstract

**Background:** Acetabular fracture involves whether superior articular weight bearing area and stability of the hip are assessed by acetabular roof arc angles comprising medial, anterior and posterior. Many previous studies, based on clinical, biomechanics and anatomic superior articular surface of acetabulum showed different degrees of the angles. Anatomic biomechanical superior acetabular weight bearing area (ABSAWBA) of the femoral head can be identified as radiographic subchondral bone density at superior acetabular dome. The fracture passes through ABSAWBA creating traumatic hip arthritis. Therefore, acetabular roof arc angles of ABSAWBA were studied in order to find out that the most appropriate degrees of recommended acetabular roof arc angles in the previous studies had no ABSAWBA involvement.

**Materials and Methods:** ABSAWBA of femoral head was identified 68 acetabular fractures and 13 isolated pelvic fractures without unstable pelvic ring injury were enrolled. Acetabular roof arc angle was measured on anteroposterior, obturator and iliac oblique view radiographs of normal contralateral acetabulum using programmatic automation controller digital system and measurement tools.

**Results:** Average medial, anterior and posterior acetabular roof arc angles of the ABSAWBA of 94 normal acetabulum were 39.09 (7.41), 42.49 (8.15) and 55.26 (10.08) degrees, respectively.

**Conclusions:** Less than 39°, 42° and 55° of medial, anterior and posterior acetabular roof arc angles involve ABSAWBA of the femoral head. Application of the study results showed that 45°, 45° and 62° from the previous studies are the most appropriate medial, anterior and posterior acetabular roof arc angles without involvement of the ABSAWBA respectively.

**Key words:** Acetabular radiographs, acetabular roof arc angles, anatomic biomechanicalsuperior acetabular weight bearing area

**MeSH terms:** Acetabulum, radiography, fractures, biomechanics

## Introduction

The principles of management of acetabular fracture is a restoring both intraarticular fracture and adequate acetabular coverage for femoral head to achieve congruent stable hip. Acetabular fracture involving superior weight bearing area shows significantly poor results.[1,2] Moreover, stability of the hip depends on adequate acetabular coverage of the femoral head.[3,4] Roof arc angle is a method to evaluate adequate acetabular coverage and stability of the femoral head, Matta and Merritt study based on clinical findings and suggested that the fracture crosses acetabular weight bearing dome when <45° medial, anterior and posterior roof arc angles.[5,6] A biomechanical study of acetabular coverage and hip stability of Vrahas *et al*. have demonstrated that medial, anterior and posterior acetabular roof arc angles of <45°, 25° and 70° involved weight bearing portion and created instability.[7] Chuckpaiwong and Harnroongroj studies acetabular roof arc angles of anatomic superior acetabular weight bearing dome showing <46° medial, 52° anterior and 62° posterior roof arc angles involved superior weight bearing area of acetabulum.[8] The three studies confirmed only 45° of medial acetabular roof arc angle, but anterior and posterior roof arc angles were quite different and created controversial recommendation. Pauwels described superior acetabular subchondral bone density area above the femoral head as anatomic biomechanical superior acetabular weight bearing area (ABSAWBA) of the femoral head.[9-11] If there is any pathology at ABSAWBA including fractures, the articular cartilage is deteriorated and leads to osteoarthrosis hip. Hence, we studied degrees of medial, anterior and posterior

Department of Orthopaedic Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

**Address for correspondence:** Dr. Thossart Harnroongroj,
Department of Orthopedics Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.
E-mail: tmthr@mahidol.ac.th

| Access this article online | |
|---|---|
| Quick Response Code: | Website: www.ijoonline.com |
| | DOI: 10.4103/0019-5413.139858 |

acetabular roof arc angles by using ABSAWBA as a reference for reconsidering about the most appropriate degrees of acetabular roof arc angles of the previous studies without involvement of the ABSAWBA of the femoral head.

## Materials and Methods

The study was approved by the Institutional Review Board. Acetabular radiographs including anteroposterior, obturator and iliac oblique views were reviewed between 2001 and 2011, by using inclusion and exclusion criteria as follows: Inclusion criteria were acetabular fracture with normal contralateral acetabulum, pelvic fracture with stable pelvic ring, completed three view acetabular radiographs and patients aging more than 16 years old. Exclusion criteria were both acetabular fractures, pelvic fracture with unstable pelvic ring injury, history of hip dislocation, avascular necrosis of the femoral head, congenital and developmental abnormalities of hip and incomplete acetabular radiographs. Hence, 68 adult patients who sustained acetabular fractures with normal contralateral acetabulum and 13 patients who sustained pelvic fractures with stable pelvic ring were enrolled. Using programmatic automation controller digital system and measurement tools, ABSAWBA in anteroposterior, obturator and iliac oblique pelvic radiographs were identified. The medial end of ABSAWBA was definitely marked. Then, the three acetabular roof arc angles were measured 2 times as standard recommendation technique for 6 weeks interval by two orthopedic surgeons [Figure 1]. Data were recorded and calculated for mean, standard deviation and 95% confidence interval (CI). The measurements were statistically analyzed for reliability by using inter- and intra-observer error and intraclass correlation coefficient (ICC) and considered more than 0.75 as strong agreement.

## Results

94 normal acetabulum from 81 patients were studied. The patients consisted of 60 males, 21 females, ages ranged from 16 to 60 years old (mean 37.15 ± 12.33 years). The enrolled acetabuli consisted of 36 lefts, 32 rights and 13 bilateral. Average medial, anterior and posterior acetabular roof arc angles of ABSAWBA were 39.09° ± 7.41 (95% CI 37.57°, 40.60°), 42.49° ± 8.15 (95% CI 40.82°, 44.16°) and 55.26° ± 10.08 (95% CI 53.19°, 57.32°), respectively. ICCs for inter- and intra-observer reliability of all measurements ranged from 0.81 to 0.89 [Table 1].

## Discussion

The ABSAWBA of the femoral head is radiographic subchondral bone density at superior acetabular dome and covers 360° in a horizontal plane around superior quadrant of the femoral head.[9-11] So that ABSAWBA can be demonstrated in pelvic radiographs including anteroposterior, iliac and obturator oblique views of pelvis. The ABSAWBA is very important biomechanics of superior

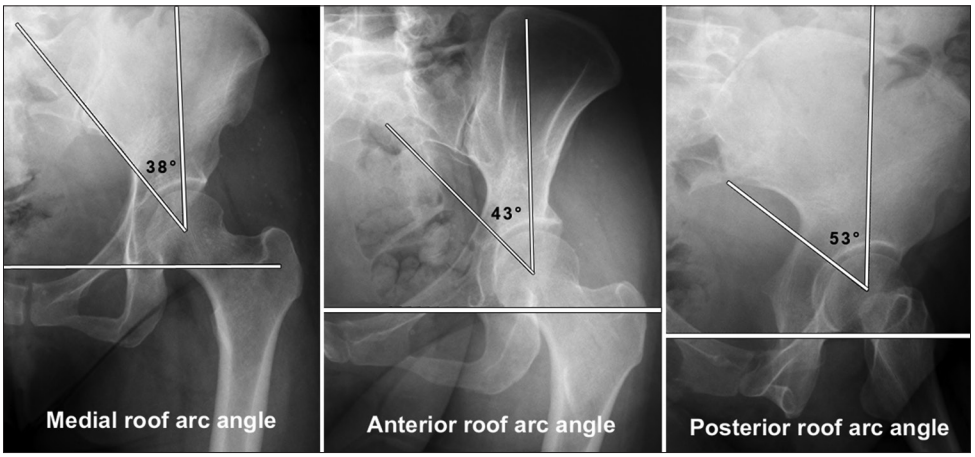


**Figure 1:** Medial, anterior and posterior roof arc angles in anteroposterior, obturator and iliac oblique acetabular radiographs were measured using anatomic biomechanical superior acetabular weight bearing area as reference

Table 1: Medial, anterior and posterior acetabular roof arc angles based on ABSAWBA and ICCs of the measurements

| Roof arc angles (°) | Minimum-maximum | Median | Mean (SD) | 95% CI | ICC | | |
|---|---|---|---|---|---|---|---|
| | | | | | Intra-observer 1 | Intra-observer 2 | Inter-observer |
| Medial | 18-54 | 39.00 | 39.09 (7.41) | 37.57, 40.60 | 0.89 | 0.85 | 0.83 |
| Anterior | 26-62 | 42.00 | 42.49 (8.15) | 40.82, 44.16 | 0.87 | 0.84 | 0.79 |
| Posterior | 35-79 | 54.50 | 55.26 (10.08) | 53.19, 57.32 | 0.85 | 0.85 | 0.81 |

ABSAWBA=Anatomic biomechanical superior acetabular weight bearing area, ICC=Intraclass correlation coefficient, CI=Confidence interval, SD=Standard deviation

hip articulation. So that actabular fracture passes through ABSAWBA of the femoral head creating posttraumatic hip osteroarthritis.[1,9,10,12] Our study did not include stability of the hip. We studied only the acetabular roof arc angles of ABSAWBA in order to assess which angles in the previous studies were safe for the ABSAWBA. The three previous studies showed the corresponded medial acetabular roof arc angle of 45° although the studies were based on different references including clinical findings, biomechanics hip stability and anatomical superior articular cartilage of acetabulum. Our study showed 39° of medial acetabular roof arc angle of ABSAWBA. The figure confirmed that the 45° roof arc angle did not involve medial portion of ABSAWBA of the femoral head.[5,7,8] Hence, the most appropriate medial acetabular roof arc angle should be 45°. Vrahas *et al*. showed 25° of anterior roof arc angle providing anterior hip stability.[7] However, our study showed that anterior acetabular roof arc angle of ABSAWBA was 42°. This figure confirmed that the 25° of the roof arc angle involved anterior portion of the ABSAWBA of the femoral head although the angle can provide hip stability. The study of Chuckpaiwong and Harnroongroj showed 52° of anterior acetabular roof arc angle although there is no involvement of the anterior portion of the ABSAWBA when comparing with our study of 42° anterior roof arc angle.[8] Moreover, 25° anterior roof arc angle of Vrahas *et al*. and 42° of our study meant that 52° anterior roof arc angle of Chuckpaiwong and Harnroongroj might be over degrees of the angle.[7,8] The reason is that the ideal transverse osteotomy was fixed references between greater sciatic notch and juxtatectal superior acetabular cartilage of acetabulum. Therefore, anterior direction of the osteotomy ran straightly downwards far from anterior inferior iliac spine. Anterior roof arc angle of our study showed 42° which confirmed that 45° anterior roof arc angle of Matta suggestion held no involvement of anterior portion of ABSAWBA of the femoral head [Table 2].[5,6] Hence, the most appropriate anterior roof arc angle should not be < 45°. 45° of posterior roof arc angle exhibited as Matta suggestion comparing with 55° posterior roof arc angle of our study showed that there was the involvement of the posterior portion of ABSAWBA of the femoral head.[5,6] On the other hand, 70° posterior roof arc angle of Vrahas *et al*. and the 62° of Chuckpaiwong and Harnroongroj showed no involvement of posterior portion of the ABSAWBA when comparing with 55° posterior acetabular roof arc angle of our study.[7,8] But 70° of Vrahas *et al*. showed very low transverse fracture below ischal spine. At this level, the fracture included part of posterior acetabular wall and position of femoral head is high degrees of flexion, the fracture mostly creates posterior acetabular wall fracture and dislocation hip.[4] 62° of posterior acetabular roof arc angle of Chuckpaiwong and Harnroongroj included posterior end of anatomic superior articular cartilage of acetabulum because the transverse osteotomy started from greater sciatic notch passing through juxtatectal area of acetabulum and excluding posterior acetabular wall by the osteotomy. Moreover, the 62° posterior acetabular roof arc angle had confirmed no involvement of posterior portion of the ABSAWBA in our study. Hence, the most appropriate posterior acetabular roof arc angle should be 62°. However, ABSAWBA roof arc angles are not applicable for displaced acetabular fractures because medial end of ABSAWBA can hardly be identified; including the fracture creates distortion of ABSAWBA. Hence, our study of the roof arc angles of normal ABSAWBA needed only to clarify precisely the ranges below which the ordinary roof arc angles indicate the ABSAWBA involvement by the acetabular fractures.

**Table 2: Acetabular roof arc angles comparison with the previous studies**

| Study | Based on | Acetabular roof arc angles | | |
|---|---|---|---|---|
| | | Medial | Anterior | Posterior |
| Matta *et al*. (1988)[5] | Clinical | 45° | 45° | 45° |
| Vrahas *et al* (1999)[7] | Stability | 45° | 25° | 70° |
| Chuckpaiwong *et al*. (2009)[8] | Anatomy | 46° | 52° | 62° |
| Author's study | ABSAWBA | 39° | 42° | 55° |

ABSAWBA=Anatomic biomechanical superior acetabular weight bearing area

## Conclusion

The study showed that <39° medial, 42° anterior and 55° posterior acetabular roof arc angles involve ABSAWBA of the femoral head. So, the most appropriate medial, anterior and posterior roof arc from the previous studies without involvement of ABSAWBA should be 45°, 45°, and 62°, respectively.

## References


1. Rowe CR, Lowell JD. Prognosis of fractures of the acetabulum. J Bone Joint Surg Am 1961;43:30-59.
2. Matta JM, Anderson LM, Epstein HC, Hendricks P. Fractures of the acetabulum. A retrospective analysis. Clin Orthop Relat Res 1986;205:230-40.
3. Harnroongroj T, Suangyanon P, Tharmviboonsri T, Harnroongroj T. Posterior acetabular arc angle of the femoral head assesses instability of posterior fracture-dislocation of the hip. Int Orthop 2013;37:1141-5.
4. Harnroongroj T, Riansuwan K, Sudjai N, Harnroongroj T. Posterior acetabular arc angle of unstable posterior hip fracture-dislocation. Int Orthop 2013;37:2443-9.
5. Matta JM, Merritt PO. Displaced acetabular fractures. Clin Orthop Relat Res 1988;230:83-97.
6. Moed BR, Reilly MC. Acetabulum fractures. In: Bucholz RW, Heckman JD, Court-Brown CM, editors. Rockwood and Green's Fractures in Adults. 7th ed. Philadelphia: Lippincott Williams and Wilkins; 2009. p. 1464-523.
7. Vrahas MS, Widding KK, Thomas KA. The effects of simulated transverse, anterior column, and posterior column fractures

of the acetabulum on the stability of the hip joint. J Bone Joint Surg Am 1999;81:966-74.
8. Chuckpaiwong B, Suwanwong P, Harnroongroj T. Roof-arc angle and weight-bearing area of the acetabulum. Injury 2009;40:1064-6.
9. Pauwels F. Biomechanics of the Normal and Diseased Hip: theoretical Foundation, Technique, and Results of Treatment: an Atlas. Berlin: Springer-Verlag; 1976.
10. Bombelli R. Structure and Function in Normal and Abnormal Hips: how to Rescue Mechanically Jeopardized Hips. 3rd ed. Berlin: Springer-Verlag; 1993.
11. Barak MM, Lieberman DE, Hublin JJ. A Wolff in sheep's clothing: Trabecular bone adaptation in response to changes in joint loading orientation. Bone 2011;49:1141-51.
12. Magu NK, Rohilla R, Arora S. Conservatively treated acetabular fractures: A retrospective analysis. Indian J Orthop 2012;46:36-45.

**How to cite this article:** Harnroongroj T, Wattanakaewsripetch M, Sudjai N, Harnroongroj T. Acetabular roof arc angles and anatomic biomechanical superior acetabular weight bearing area. Indian J Orthop 2014;48:484-7.

**Source of Support:** Nil, **Conflict of Interest:** None.