A New Standardized Method for Measuring Cup Anteversion after Total Hip Arthroplasty from Plain Radiograph

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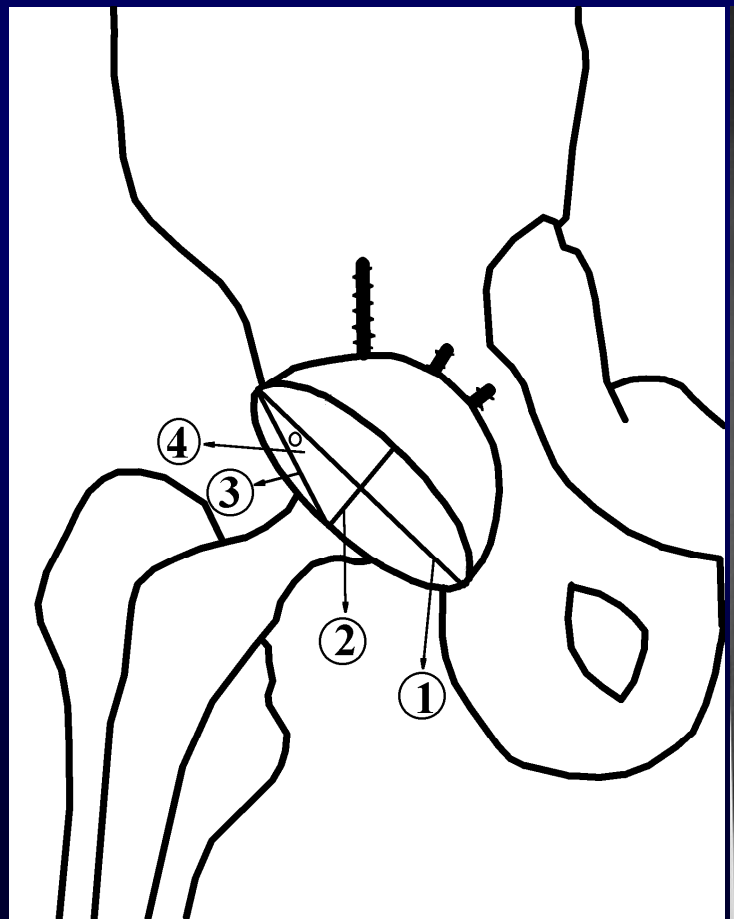
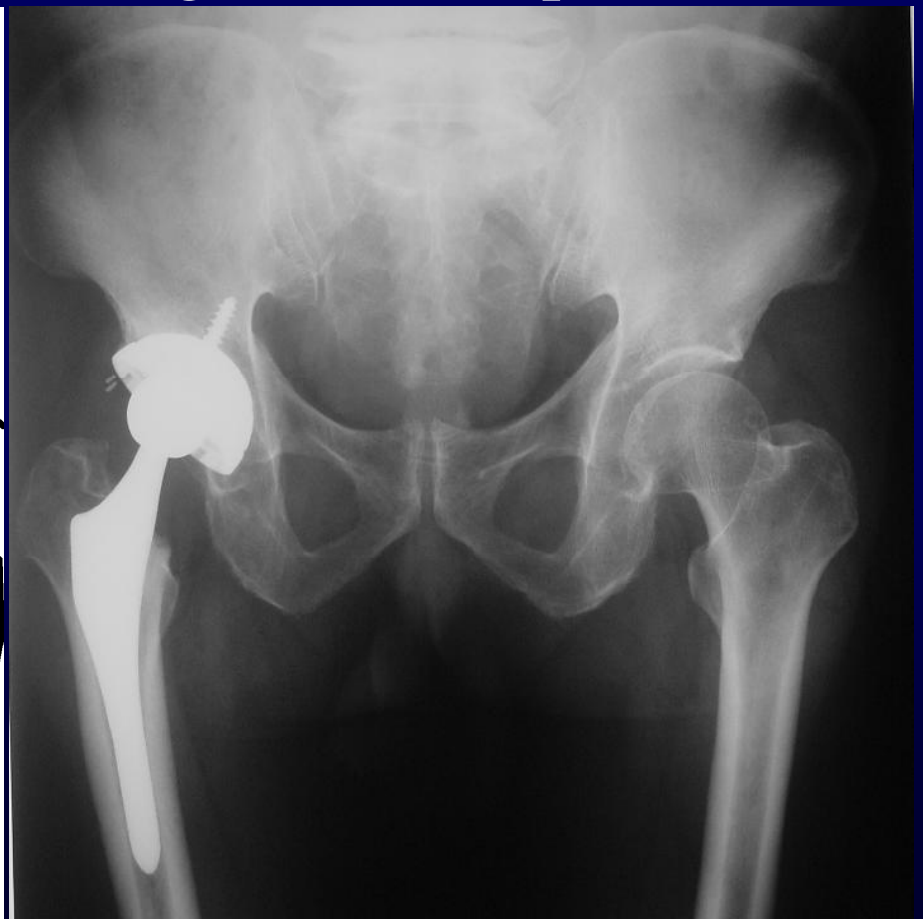
Introduction

- The anteversion of cup is an important prognostic factor after total hip arthroplasty.
- Rarely be discussed due to
  - difficulty to measure it
  - difficulty to achieve standard position

Measuring Methods

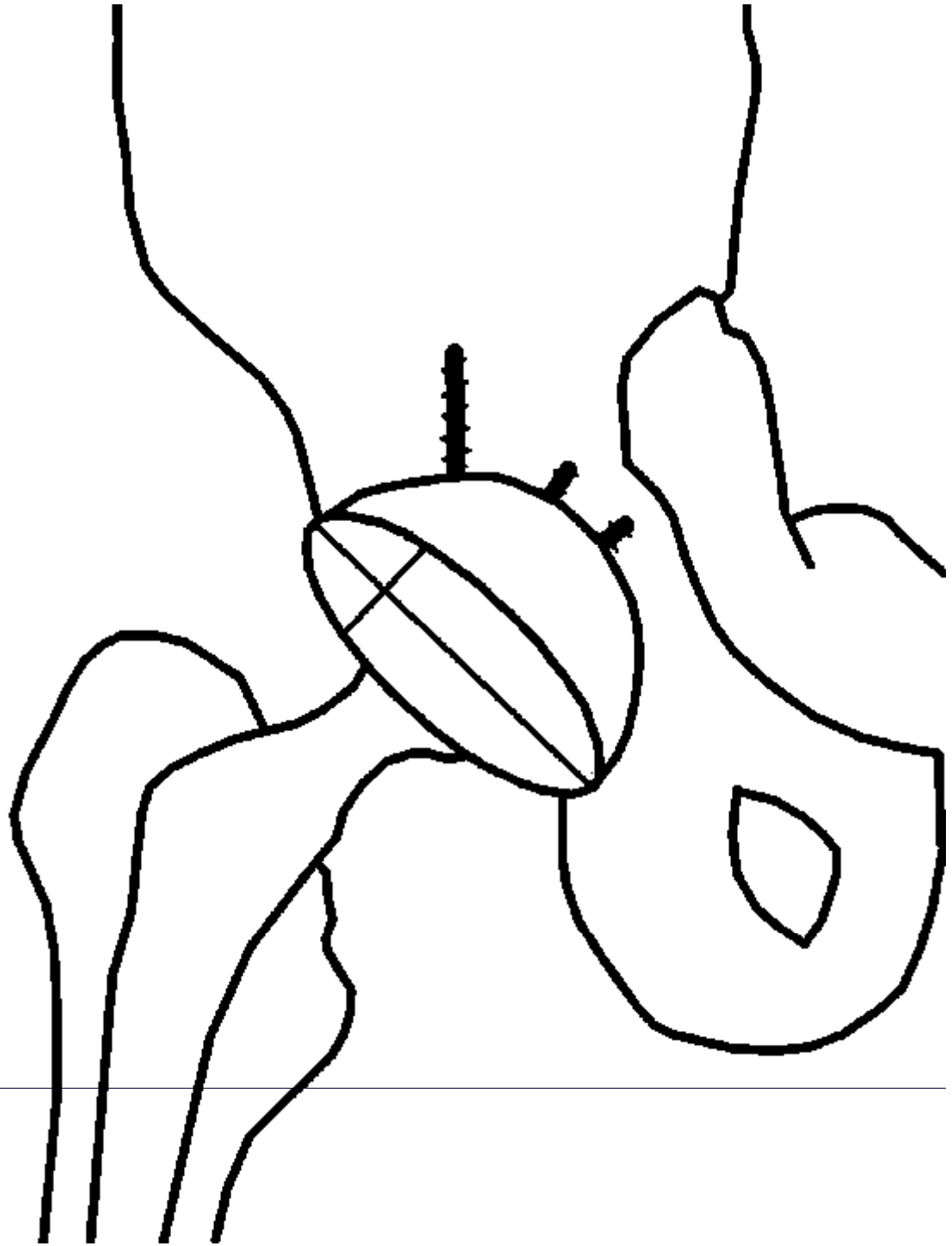
- Lewinnek's method
  - Measure short axis and long axis of ellipse



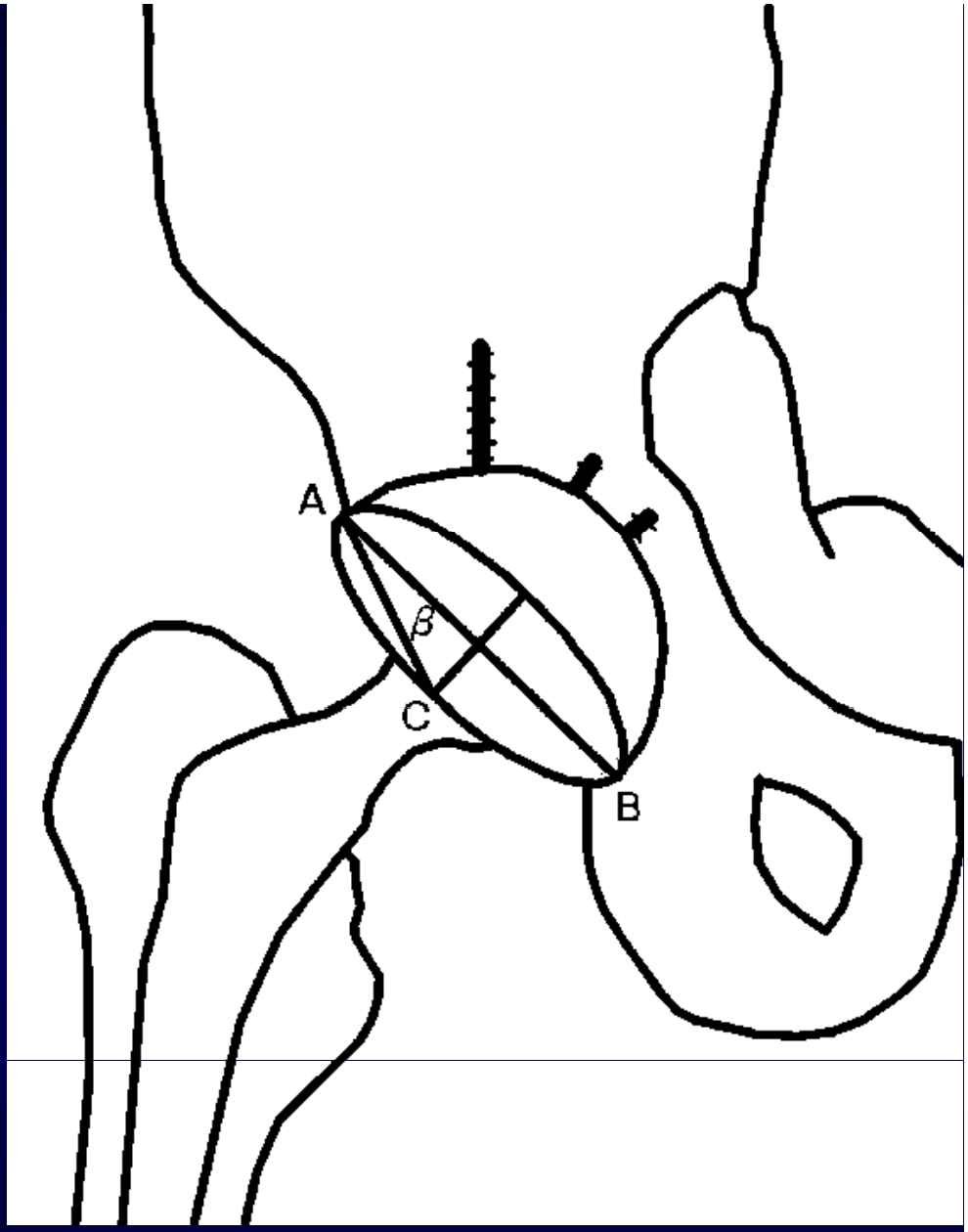


Pradhan's Method

- Measure the ellipse at 0.4r
- To elimate the overlapping femoral head
- *J Bone Joint Surg [Br]* 1999;81-B(3):431-5

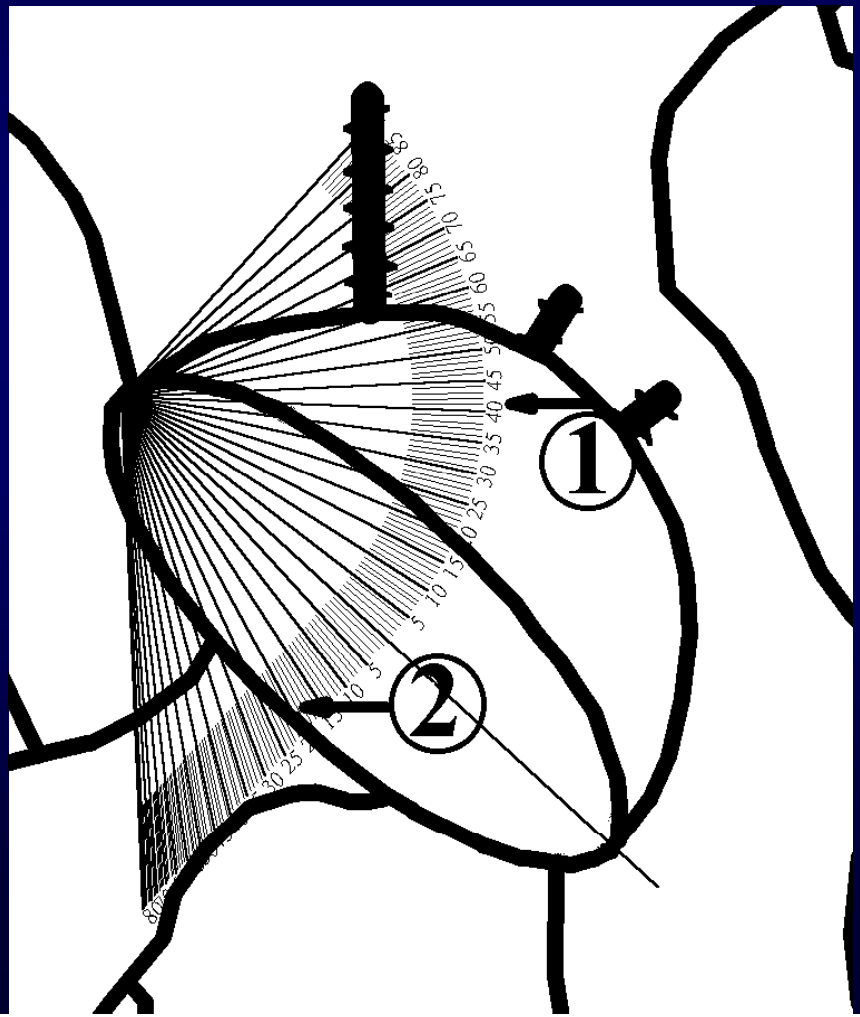


Liaw's Method of Measuring Anteversion

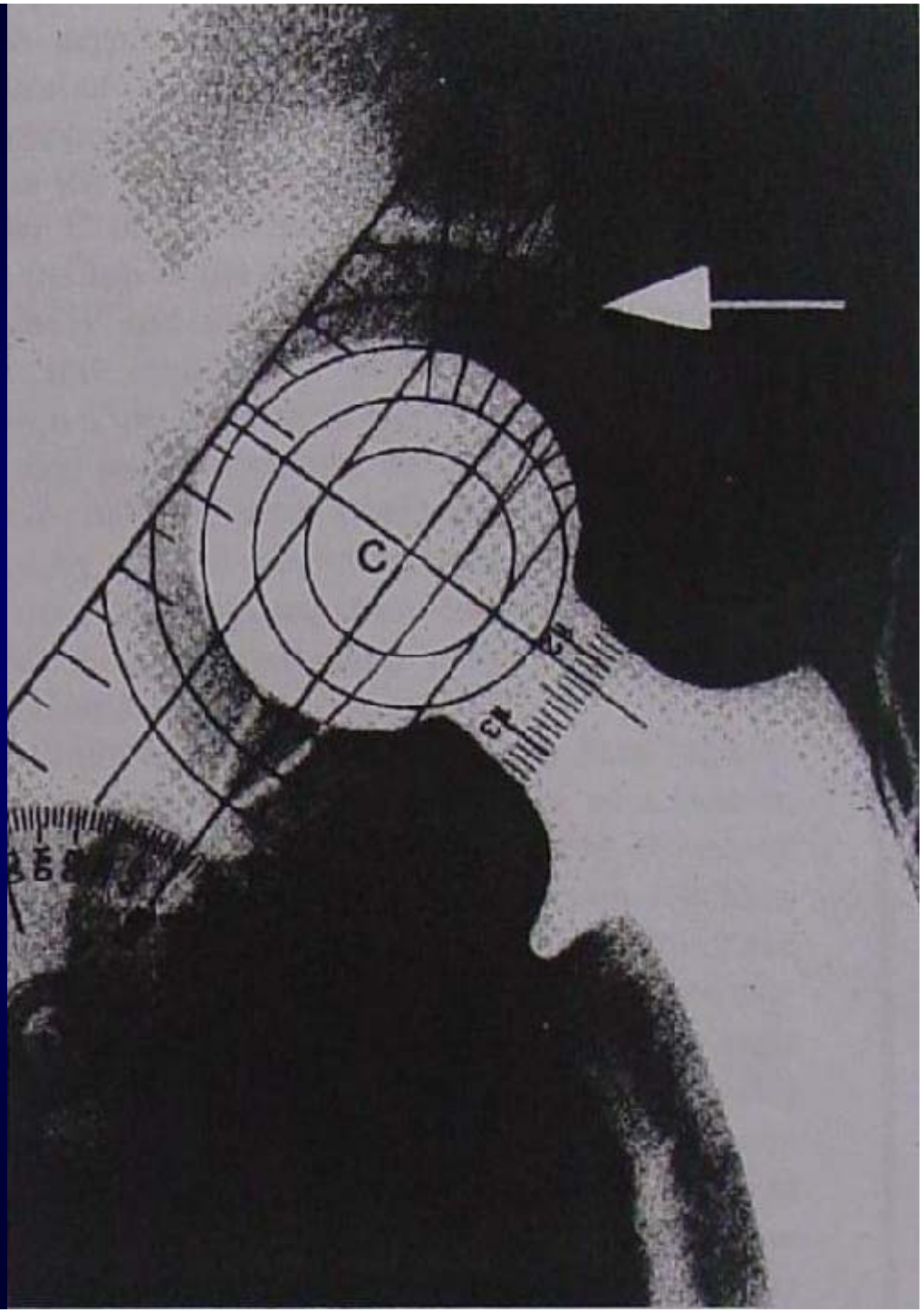


- $\beta = \tan^{-1}$ (short axis of the ellipse / long axis of the ellipse)

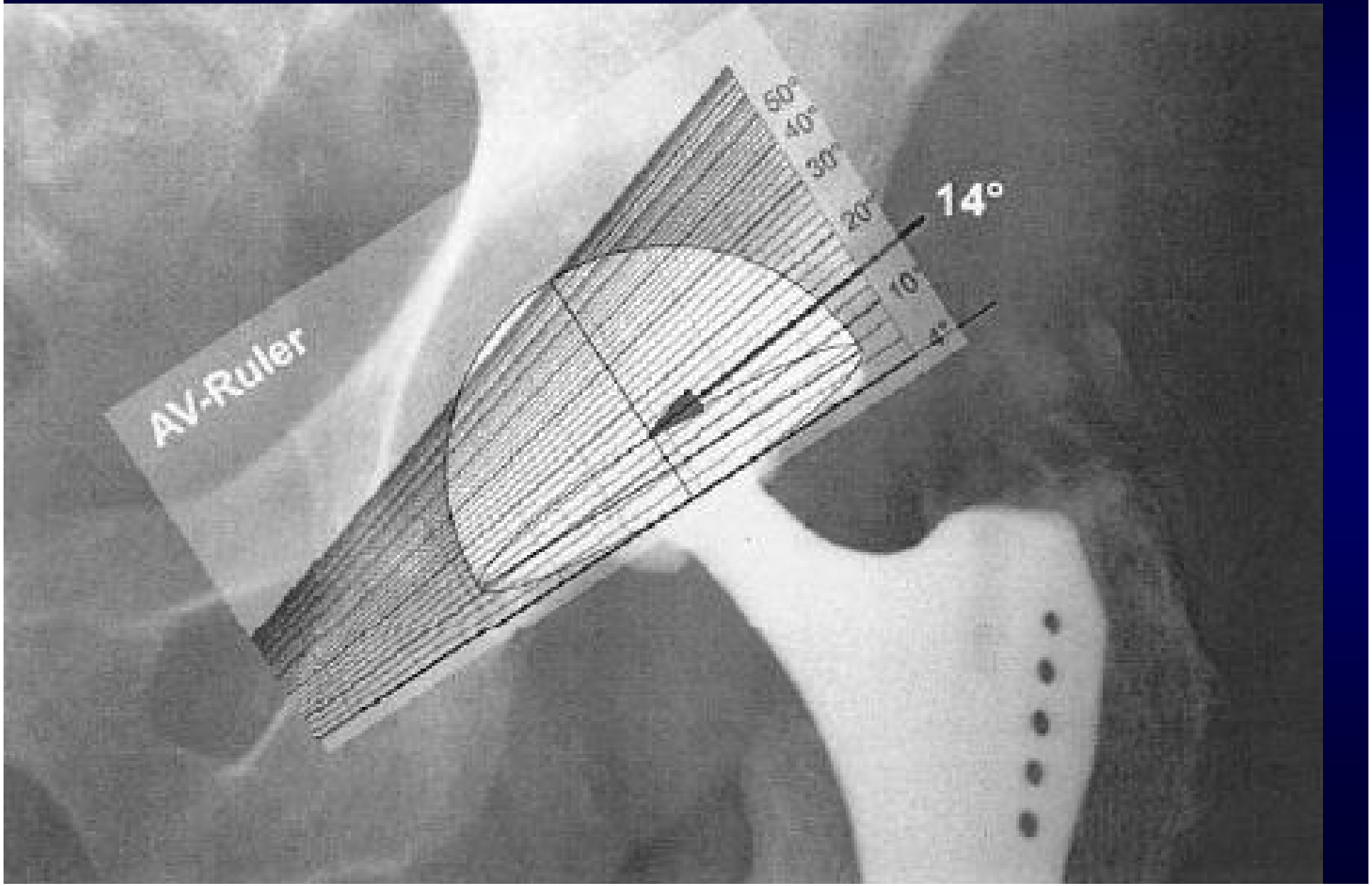
Liaw's Method



Fabeck's Method



Widmer Method



Standard Position?

- X ray tube position
- Patient position
- X ray film position

X Ray Tube Position

- 100 cm above the patient
- Pelvis AP view
  - Centered at symphysis pubis
- Hip AP view
  - Centered at femoral head (acetabulum)

X Ray Film Position

- Pelvis AP view
  - Perpendicular to X ray tube to symphysis pubis
- Hip AP view
  - Perpendicular to X ray tube to femoral head
- Below patient

Patient Position

- No tilt
- No rotation
- Pelvis AP view
  - Line X ray tube to symphysis pubis is parallel to symphysis pubis to sacrococcygeal junction
- Hip AP view
  - Line X ray tube to femoral head is parallel to symphysis pubis to sacrococcygeal junction

Position Problem

- To keep X ray tube and film in good position is easy.
- Hard to obtain good position of patient.

Patient Position Problem

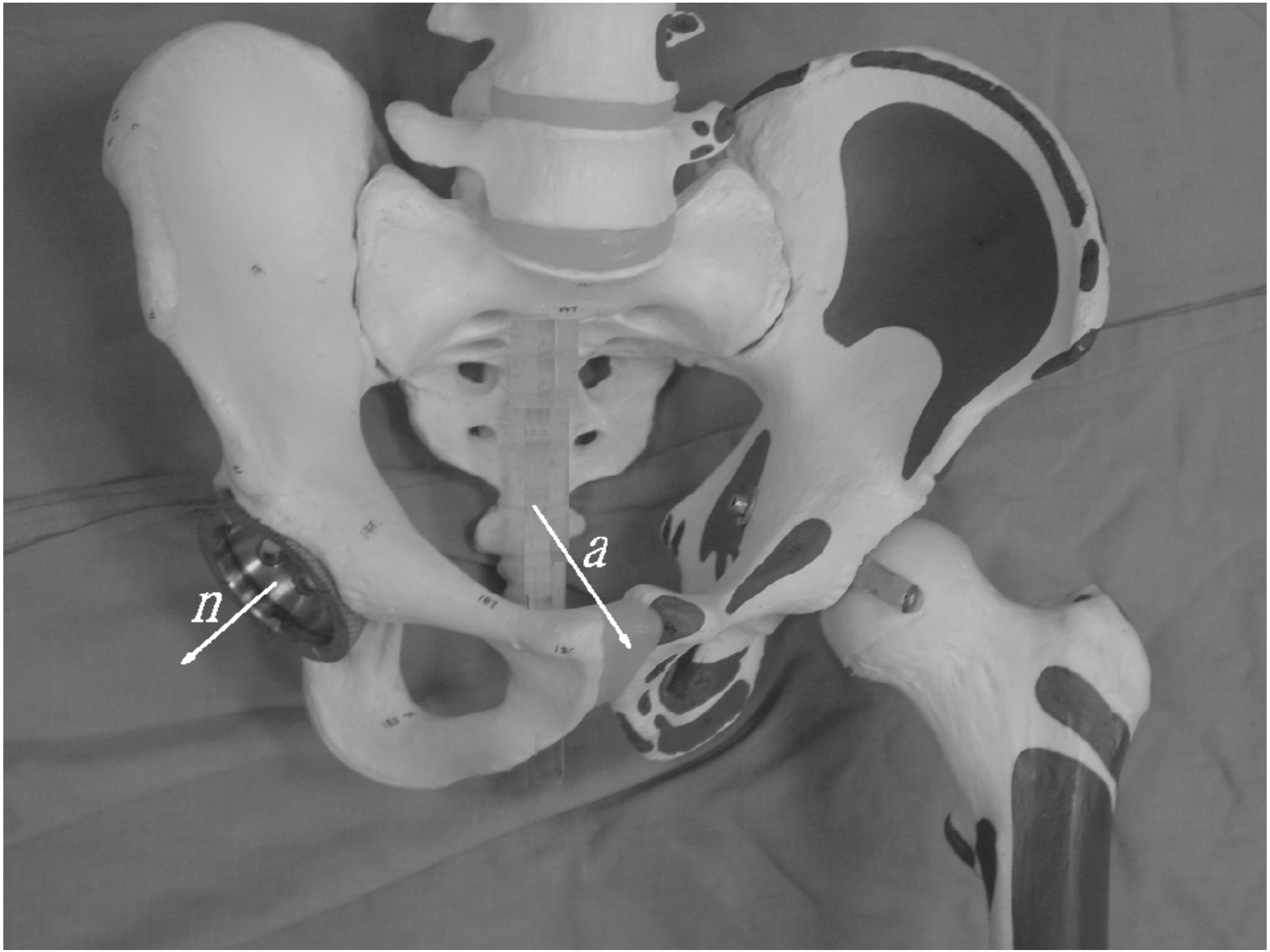
- We can take X ray again and again until we obtain good patient position.
- Jaramaz's method uses CT (computer tomography) to obtain three dimensional relationship and then calculate the anteversion.
- *Clin. Orthop.*, 354:70–80, 1998.

Our Solution

- Take X ray without concerning patient's position.
- Find clues on this X ray and calculate the patient's position.
- Then correct the anteversion by the patient's position.

Our Definition of Anteversion

- Pelvis radiographic axis: the axis from center of sacrococcygeal junction pointed toward upper pole of symphysis pubis.
  - The upper pole of symphysis pubis means the mid point of upper end of interpubic fibracartilage.
- Radiographic standardized anteversion: the angle between the plane of acetabulum and pelvis radiographic axis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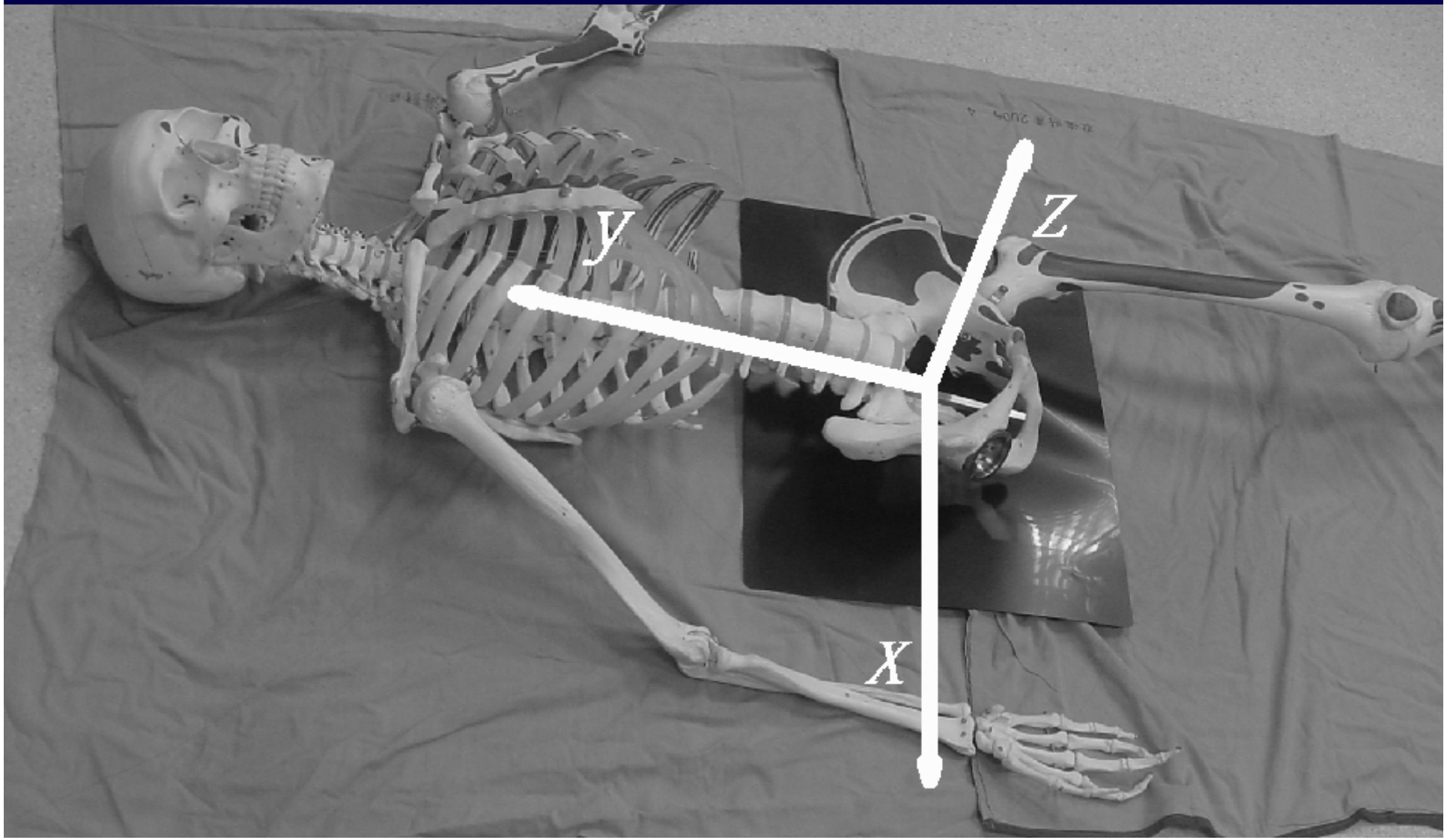
Obtain Patient's Position

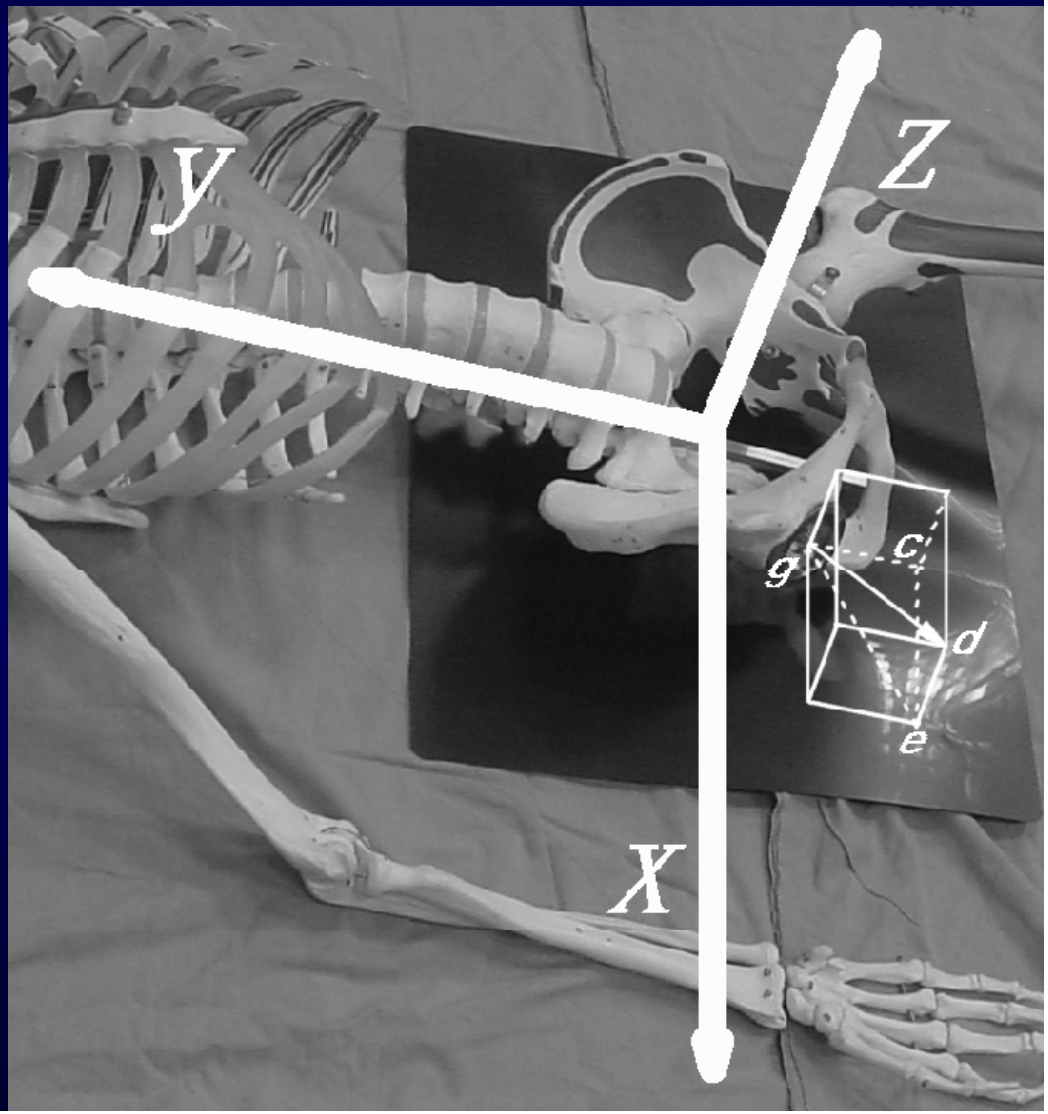
- Define Cartesian coordinate system
- Obtain pelvis radiographic axis from plain X ray.
- Obtain vector of pelvis radiographic axis.
- Obtain normal vector of acetabulum.
- Calculate the angle between the two vectors.

Cartesian Coordinate System



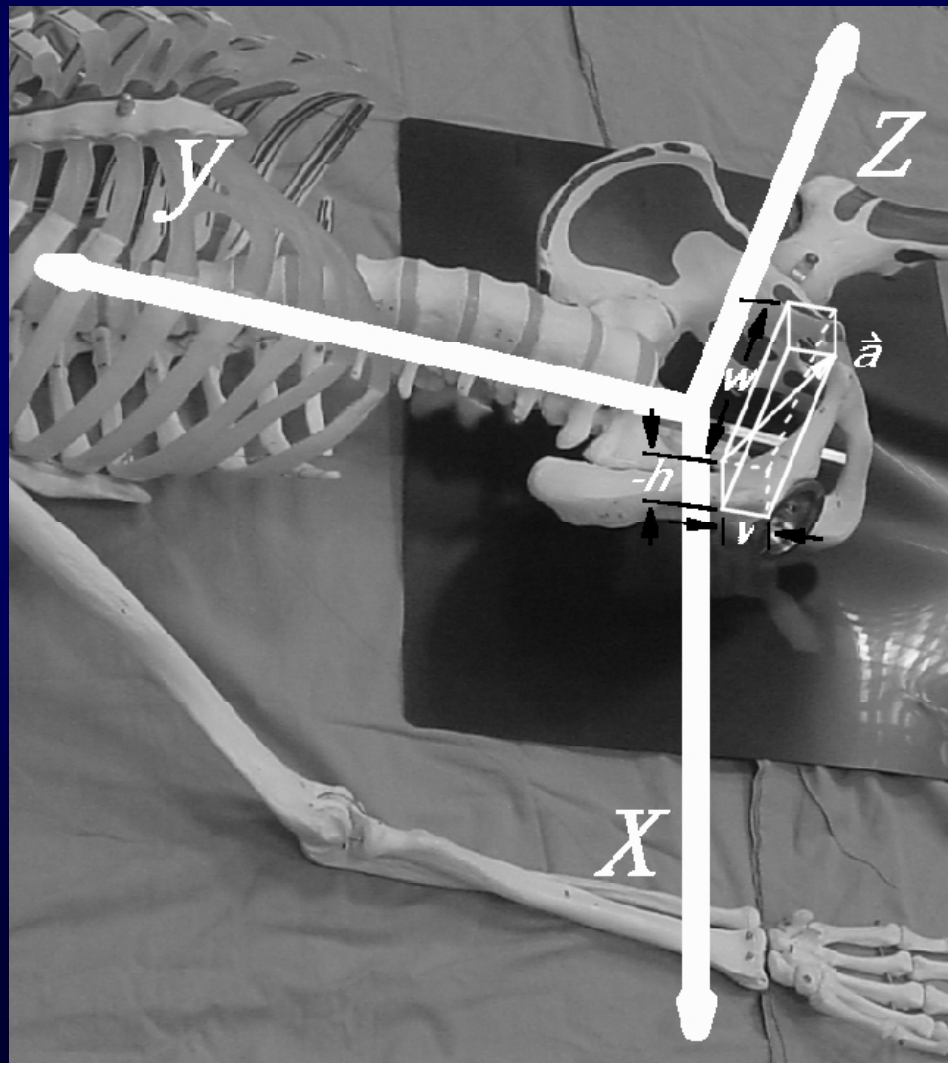
Normal Vector of Acetabulum

- Anteversion$\theta = \angle dge$
- Inclination$\varphi = \angle cge$
- Unit normal vector n= vector gd
- Vector n=
  (sinφ*cosθ, -cosφ*cosθ, sinθ)



Vector of Pelvis Radiographic Axis

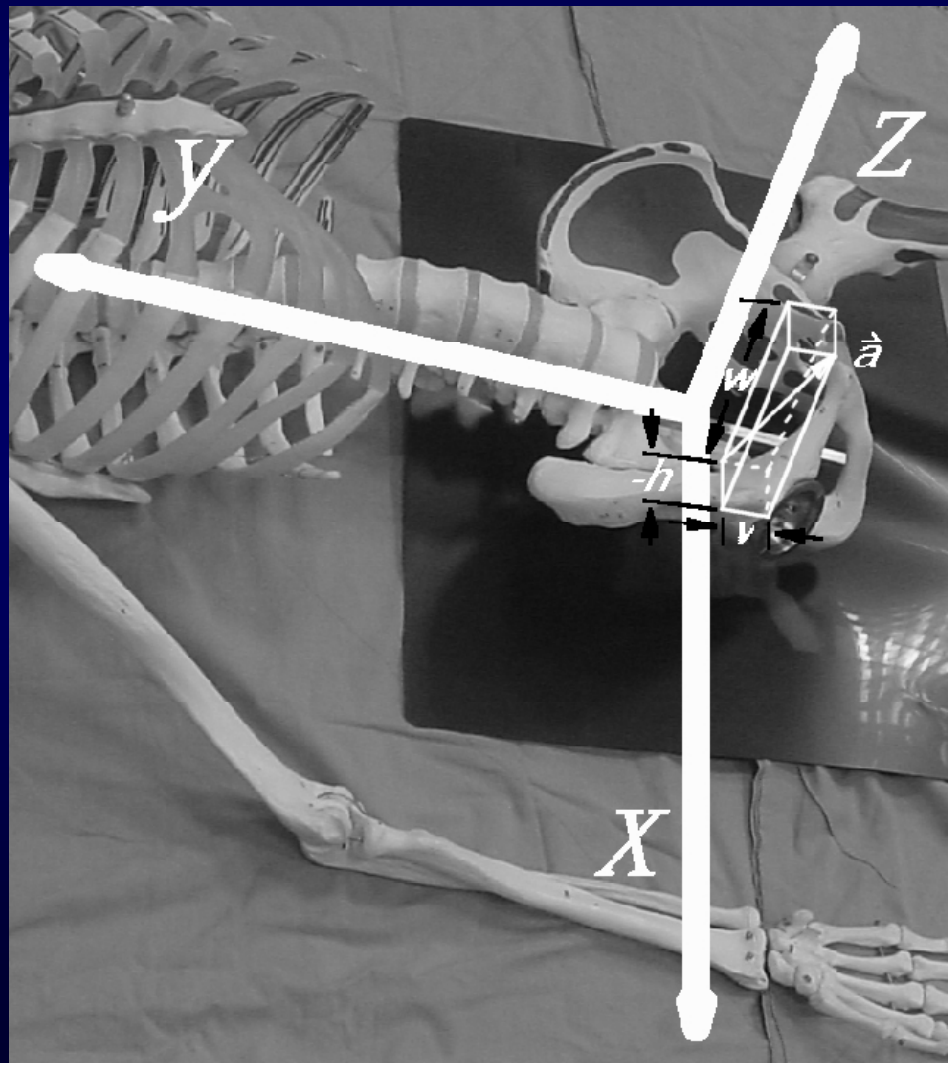
- *h* mm: horizontal displacement of sacrococcygeal junction related to upper pole of symphysis pubis in horizontal direction.
- *h* is positive if sacrococcygeal junction is between this acetabulum and the upper pole of symphysis pubis, otherwise it is negative.



Vector of Pelvis Radiographic Axis

- *v* mm: vertical displacement of sacrococcygeal junction related to upper pole of symphysis pubis in vertical direction.
- *v* is positive if sacrococcygeal junction is higher than upper pole of symphysis pubis, otherwise it is negative.
- vector *a*=

$$(-h, -v, (120^2 - h^2 - v^2)^{0.5})$$



Angle between the Two Vectors

- ω = angle between the two vectors
- cosω= (vector *a* dot vector *n*)/(length of vector *a** length of vector *n*)
- ω= arc cos((vector *a* dot vector *n*)/(length of vector *a** length of vector *n*))

Radiographic Standardized Anteversion

- radiographic standardized anteversion=

  90 degrees – ω

  $=90 \text{ degrees} -$

  $\arccos((-h * \sin\varphi * \cos\theta + v * \cos\varphi * \cos\theta + \sin\theta * (120^2 - h^2 - v^2)^{0.5})/120)$

Verification

- We collect ten patients who received total hip arthroplasty in our hospital in 1999.
- Inclusion criteria
  - radiographs include the acetabulum, symphis pubis, and sacrococcygeal junction.
- Exclusion criteria
  - Average radiographic anteversion below 10 degrees

Material and Methods

- We measure the radiographic anteversion by Lewinnek's method, and inclination, and then radiographic standardized anteversion by our method.

Results

Patient	X-rays of each patient	Average		average of the absolute deviations		Standard deviation	
		Radiographic anteversion	Standardized anteversion	Radiographic anteversion	Standardized anteversion	Radiographic anteversion	Standardized anteversion
1	3	11.43	17.92	2.55	0.22	3.32	0.31
2	6	15.62	18.86	3.06	0.62	4.66	0.72
3	4	20.25	16.75	*10.12	0.77	**13.51	0.98
4	10	19.06	32.88	2.37	1.34	3.37	1.56
5	11	20.61	23.57	3.06	1.25	4.03	1.61
6	5	34.99	28.24	2.7	0.86	3.57	1.21
7	8	15.75	26.7	0.94	0.85	1.25	1.02
8	5	18.64	18.6	1.5	0.31	2.09	0.38
9	8	14.95	7.97	3.41	0.66	4.33	0.85
10	8	12.81	15.79	0.93	0.62	1.64	0.74
	Total: 68			Average: 3.064	Average: 0.75	Average: 4.177	Average: 0.938

*maximal average of the absolute deviation of radiographic anteversion

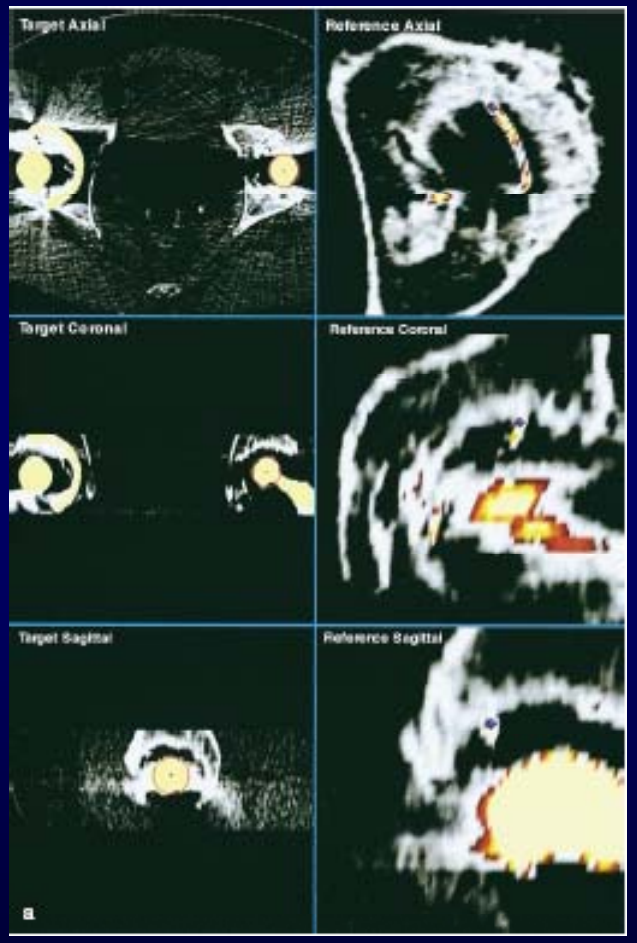
**maximal standard deviation of radiographic anteversion

Discussion

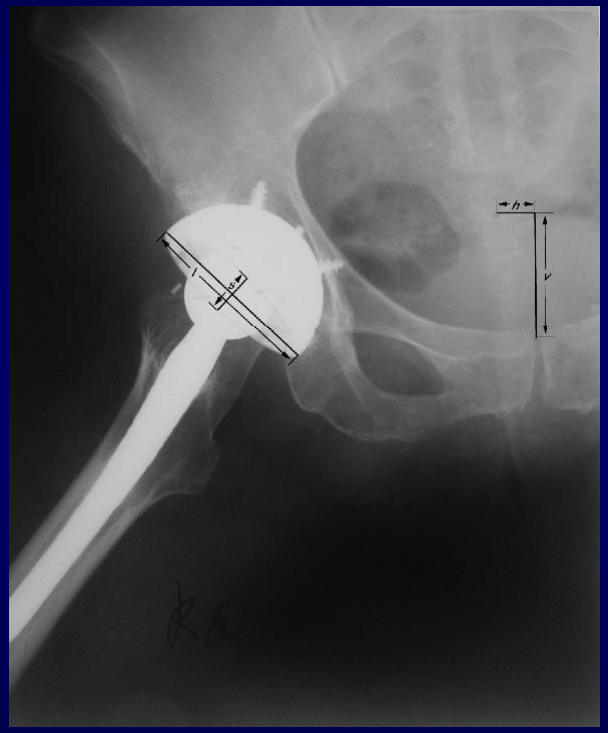
- Currently, there is no plain radiographic method to standardize anteversion.
- Our method is the first proposed two-dimensional method of standardization.

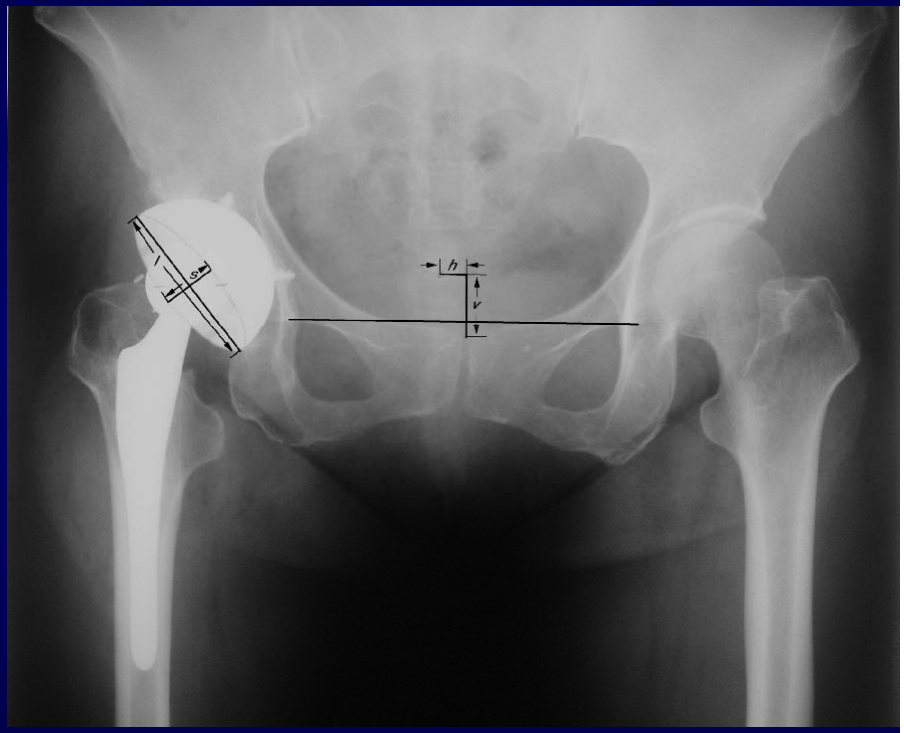
CT (Computer Tomography) Method

- *Acta Orthop Scand.*, 75:252–260, 2004.
- Mckibbin plane: include the superior iliac spines and the pubic tubercles



Anteversion or Retroversion?





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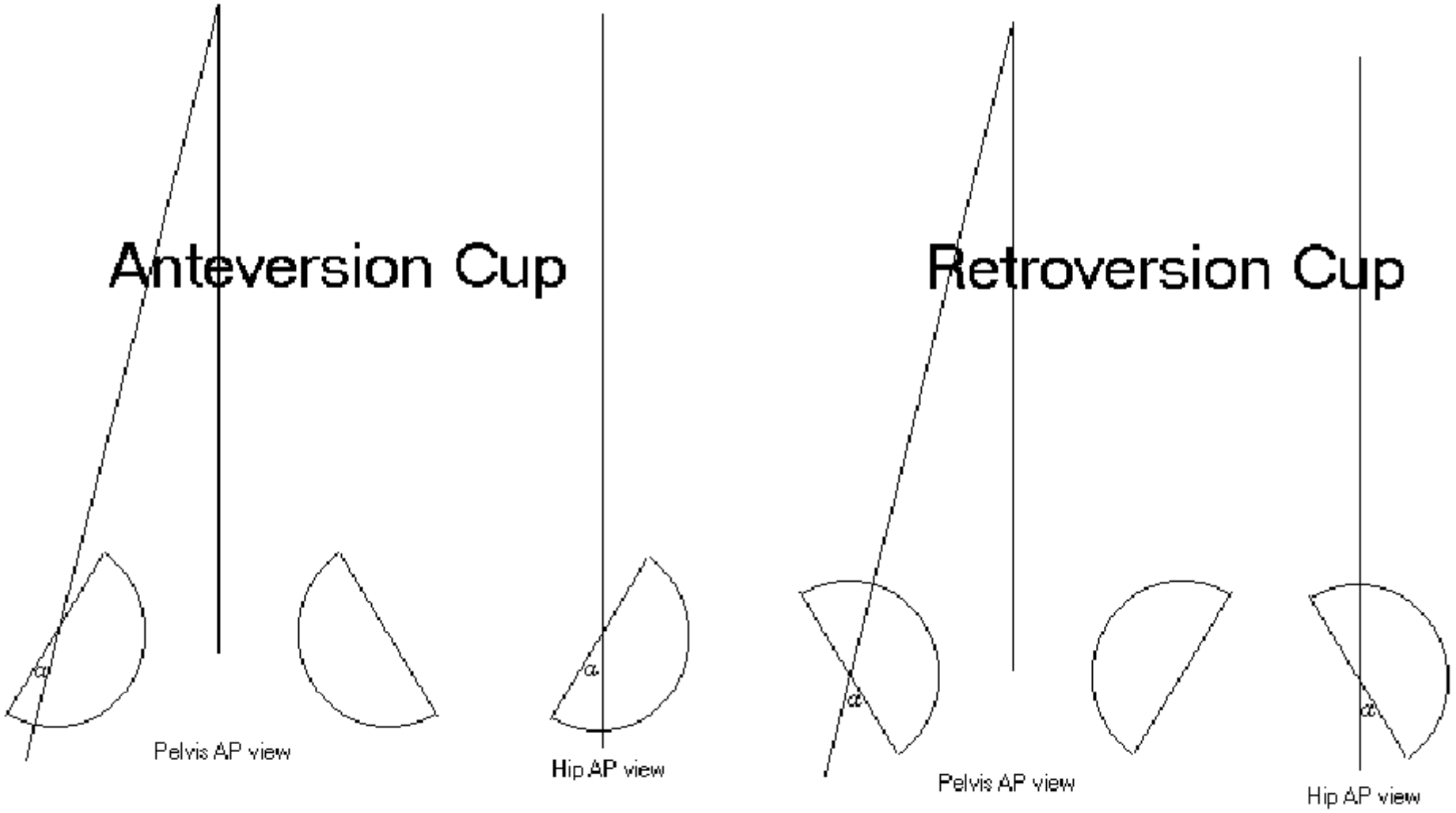

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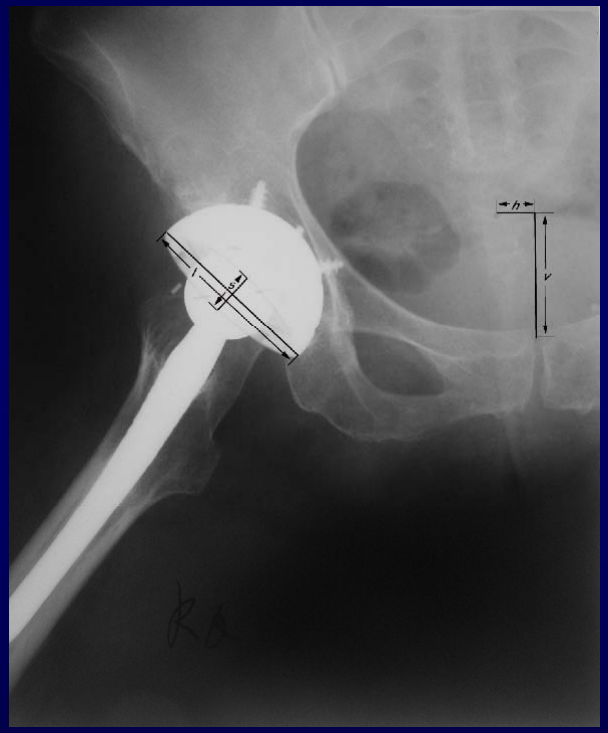

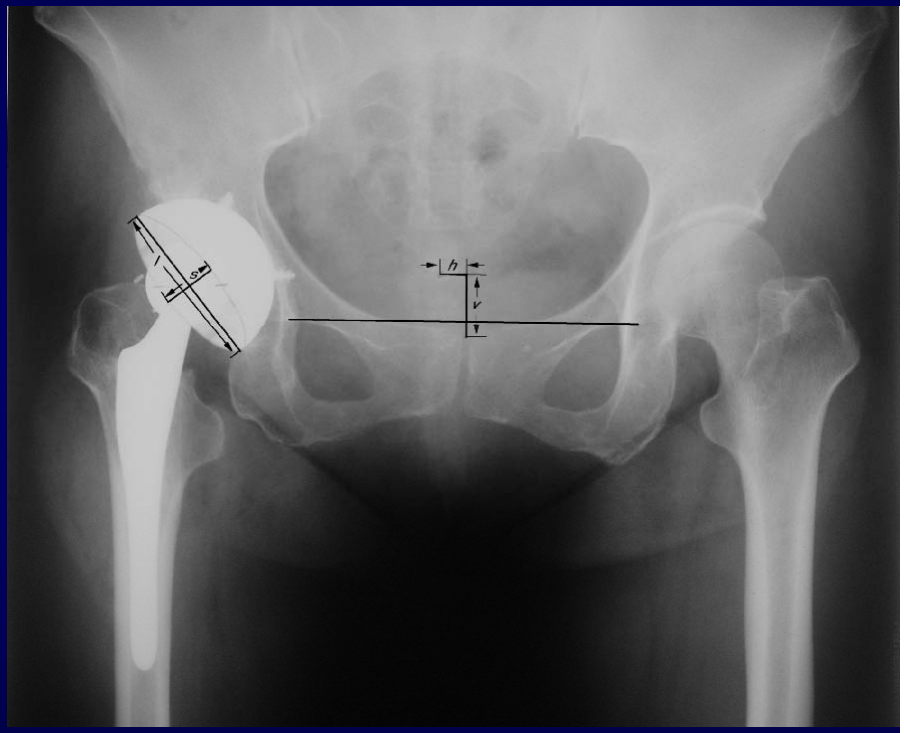

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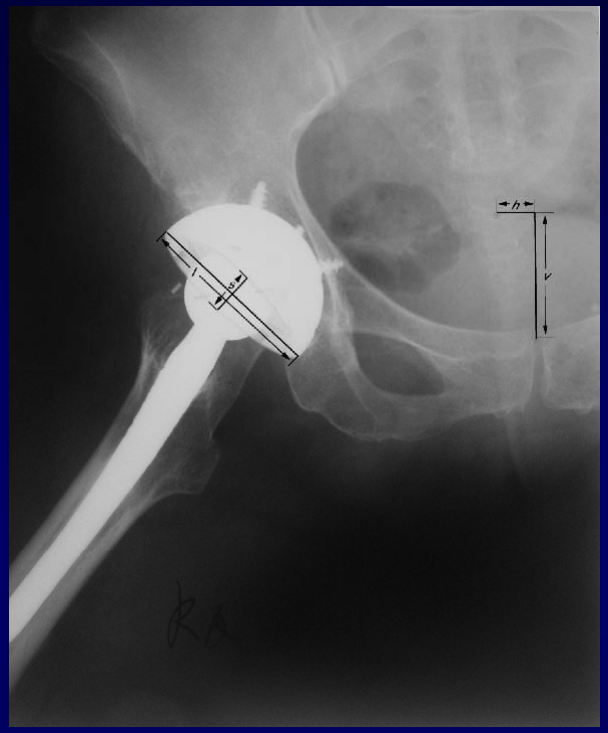


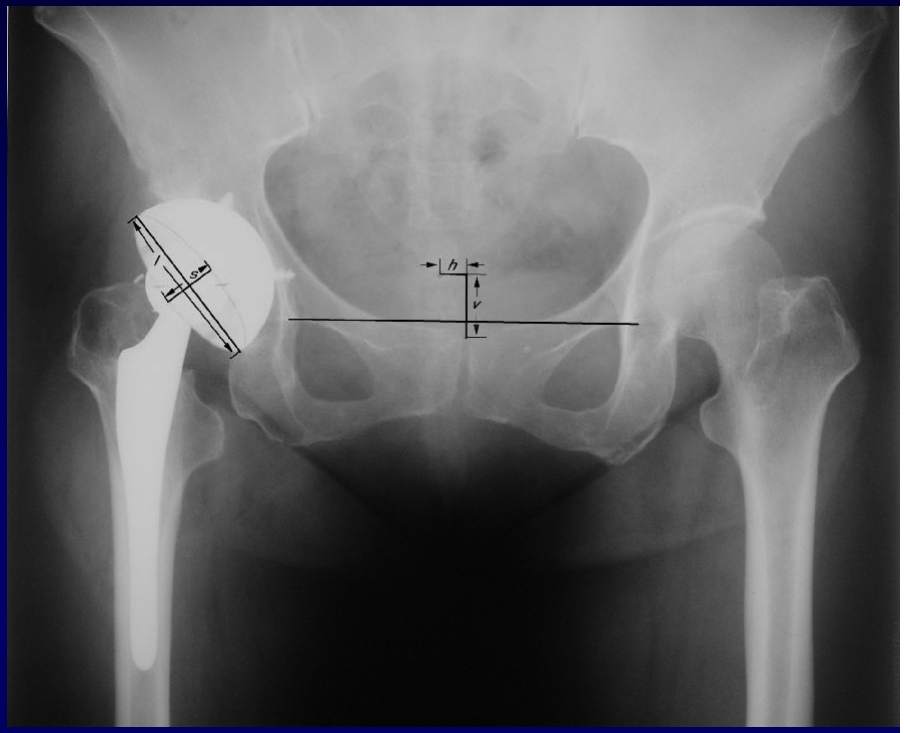
radiographic version= 14.1 degrees

h= 14.27 *v*=47.07

inclination= 48 degrees

Standardized anteversion= 23

or –3.07 degrees



radiographic version= 22.3 degrees

h= 10.2 *v*=24.54

inclination= 48 degrees

Standardized anteversion= 21.9

or –13.48 degrees

Conclusion

- We developed a standardized method of anteversion, the result shows to be better than previous method. We hope this new method could be used as standard of measuring anteversion, and help us clarify relationship between standardized anteversion and some prognostic factors.