國立臺灣大學電機資訊學院資訊工程學系
博士論文

髖臼元件方向量測
The Orientation of Acetabulum –The Definitions and Measuring Methods

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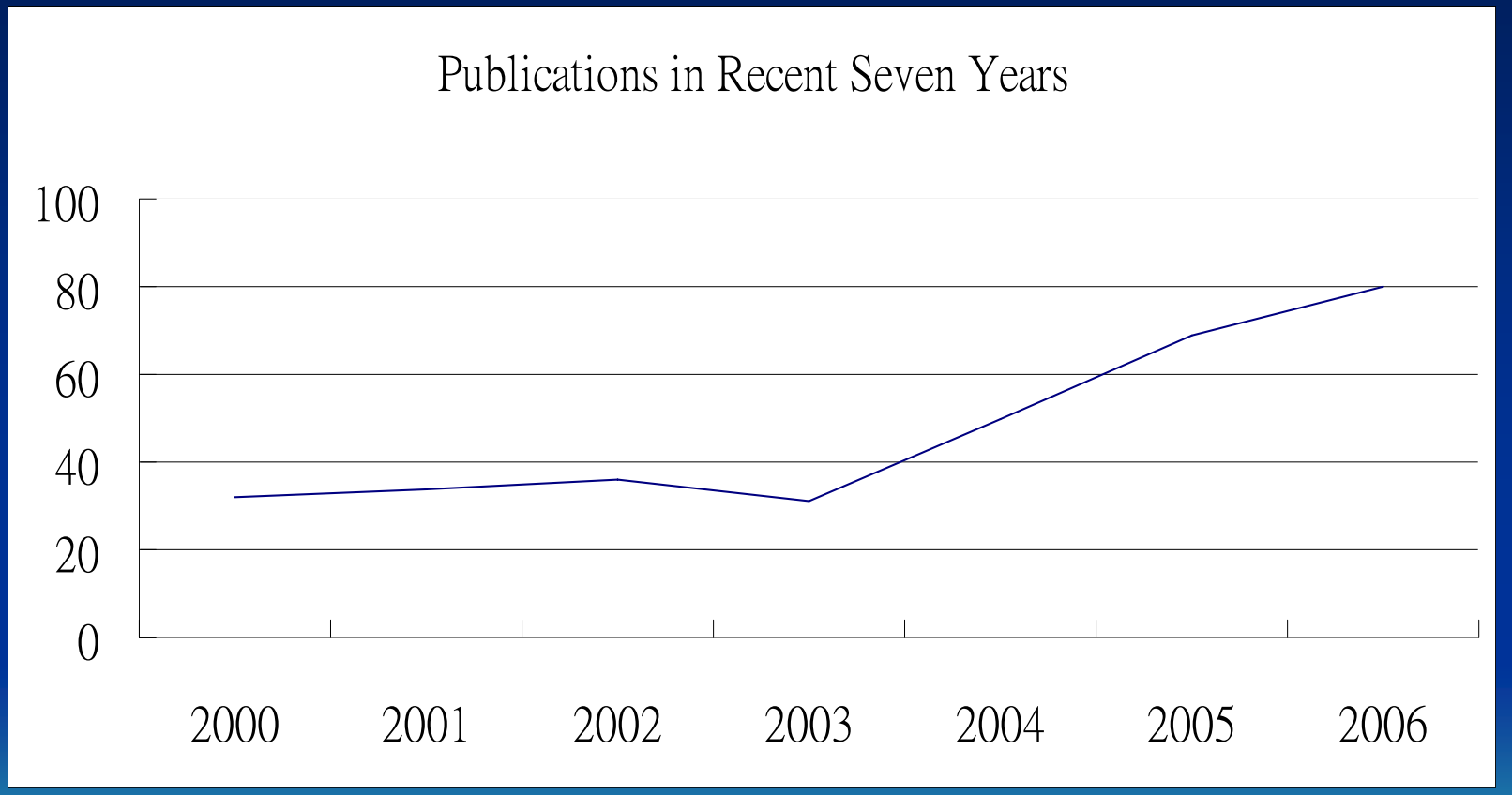
指導教授：傅楸善

Introduction

The Academic Importance of Acetabular Orientations



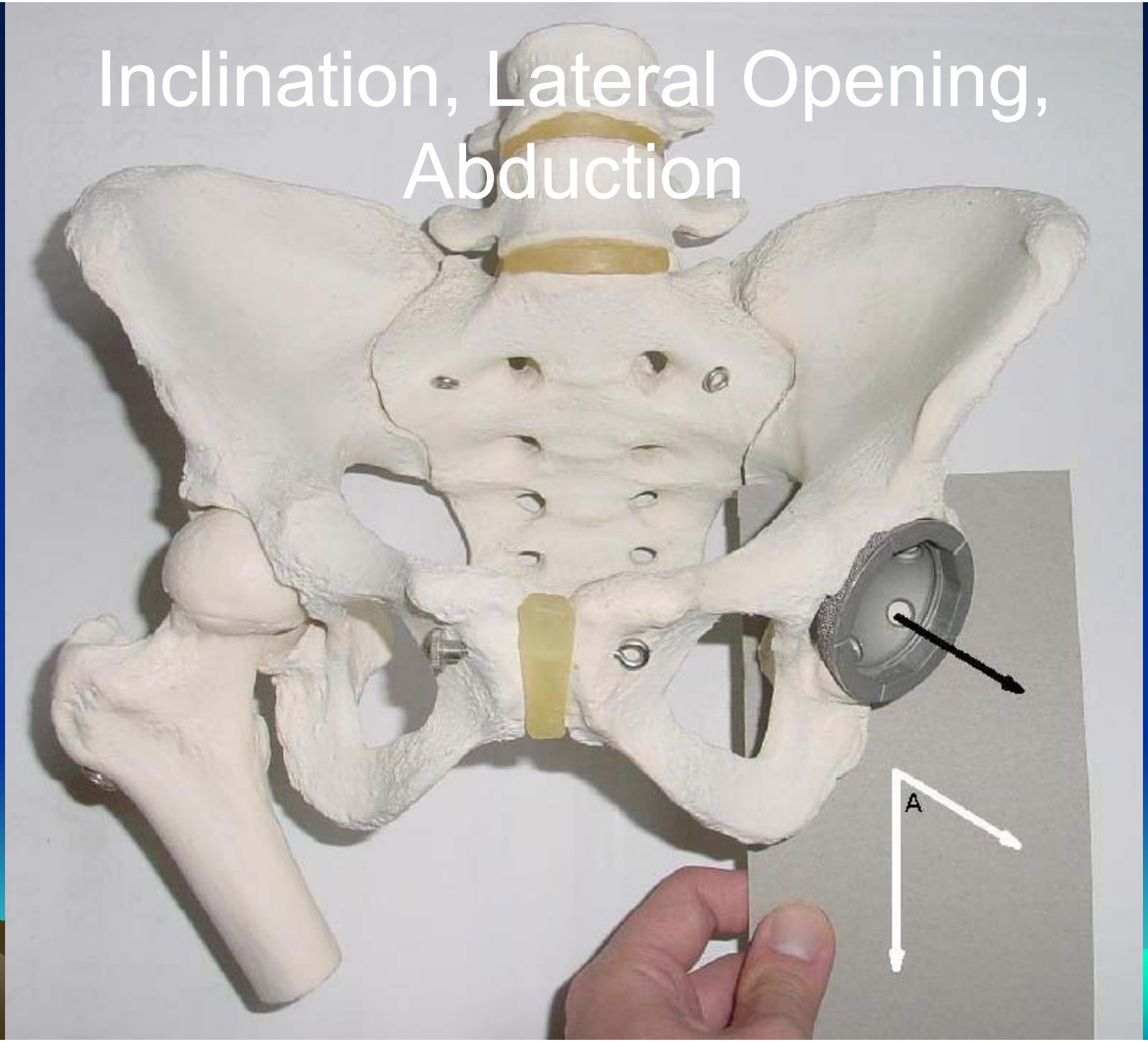
Searching in Medline with keywords of “acetabulum version”, “acetabulum anteversion”, “acetabulum retroversion”, or “acetabulum orientation”

Definitions

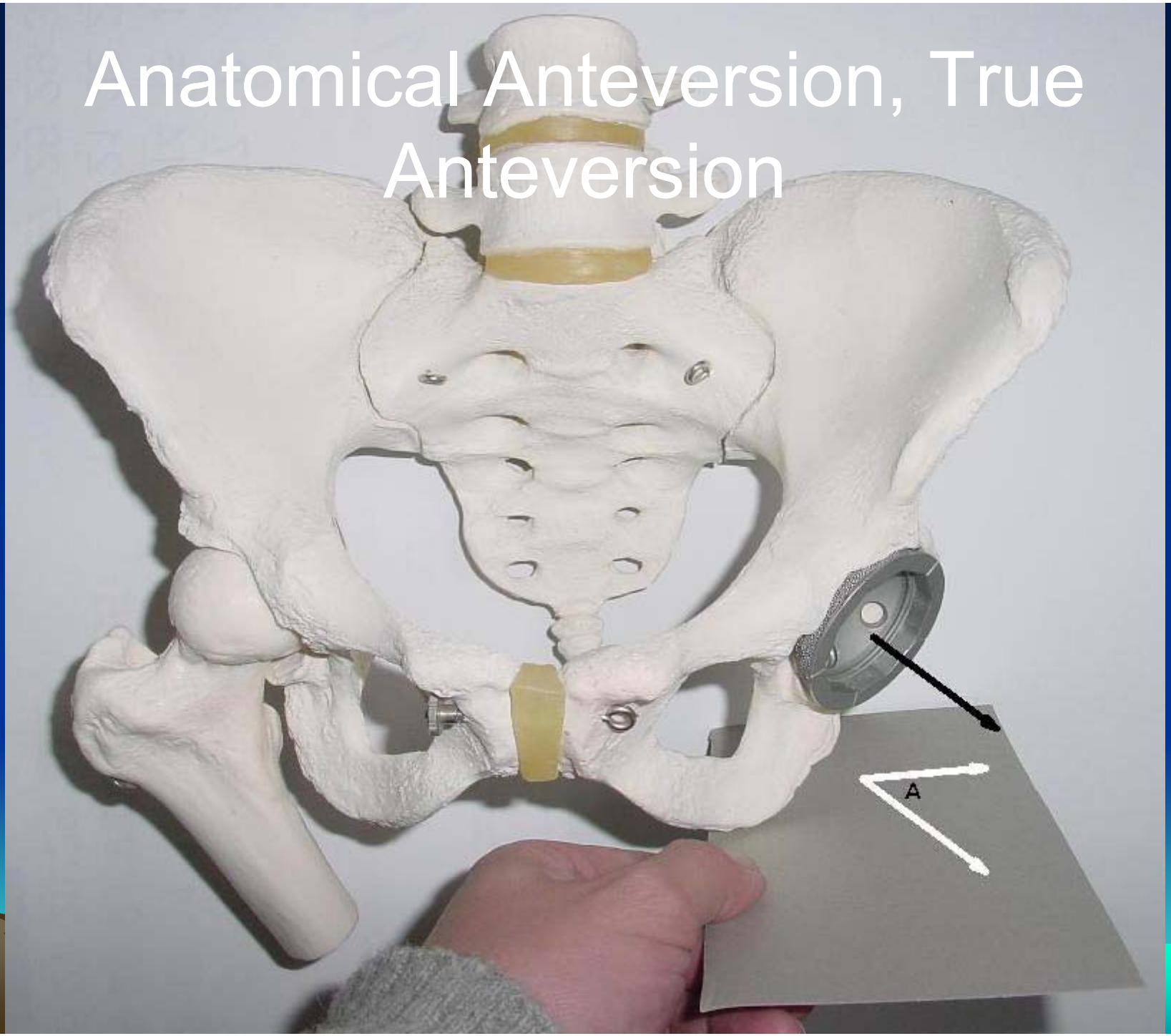
- According to Murrey's report
  - Inclination, lateral opening, abduction
  - Anatomical anteversion, true anteversion
  - Radiographic anteversion, planar anteversion
  - Operative anteversion, flexion

  - *J Bone Joint Surg Br*. 1993;75:228–232.

Inclination, Lateral Opening, Abduction

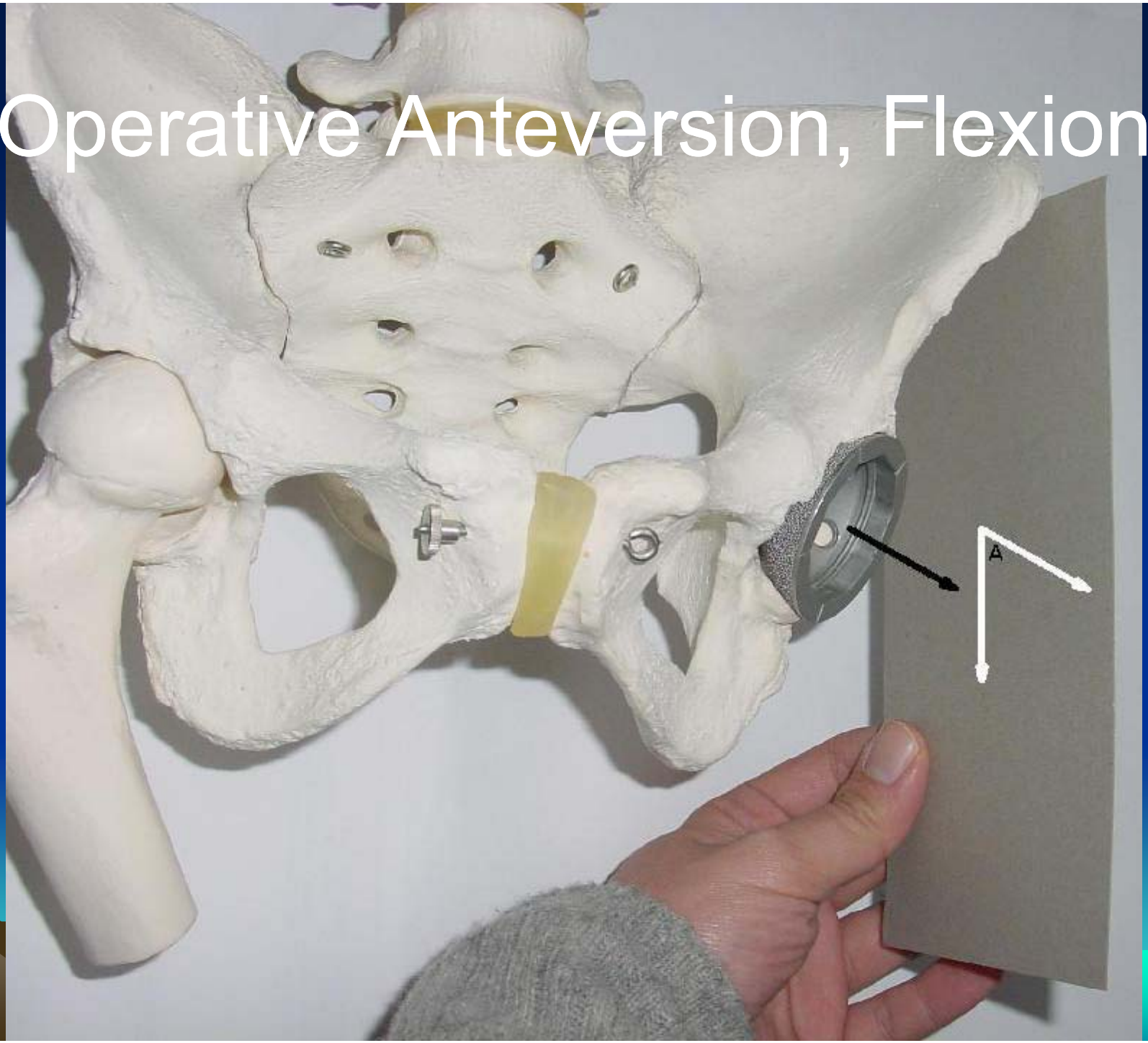


Anatomical Anteversion, True Anteversion



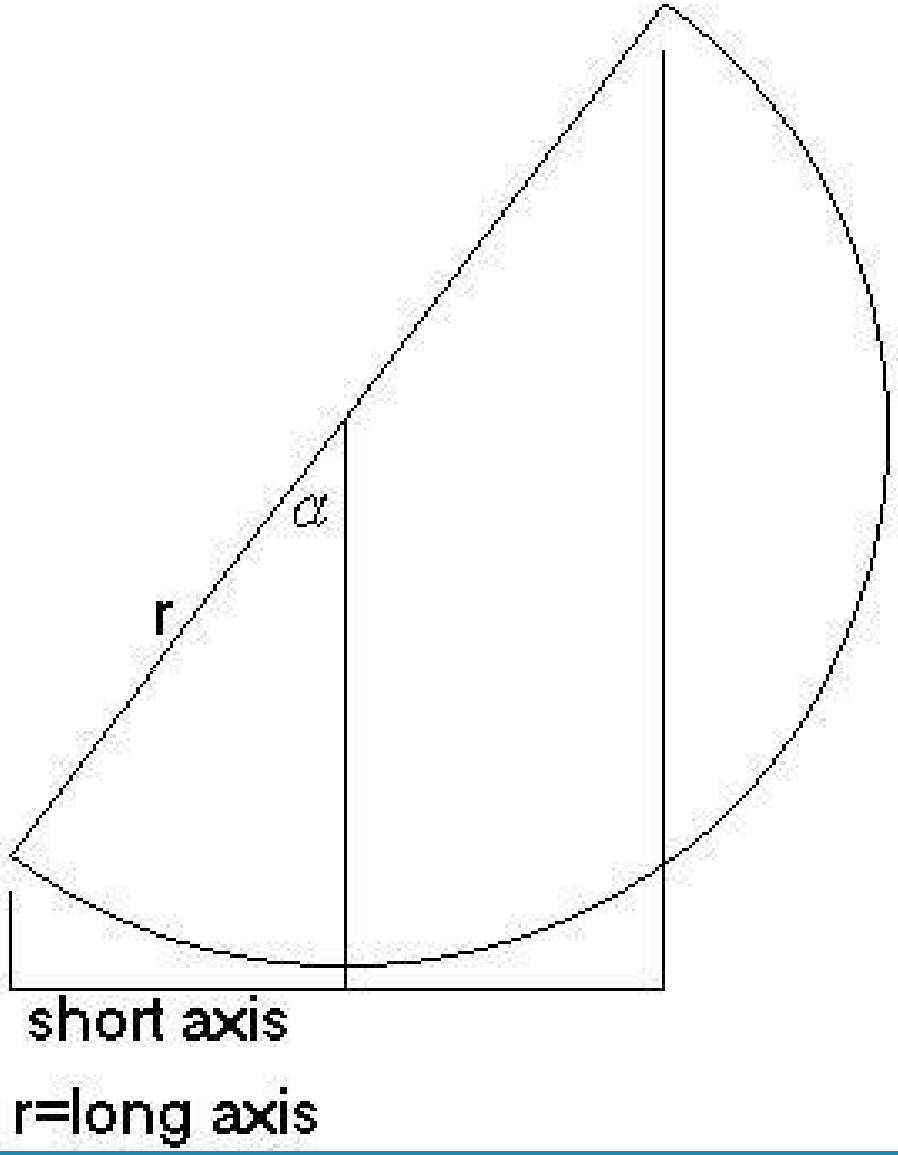
Radiographic Anteversion, Planar Anteversion

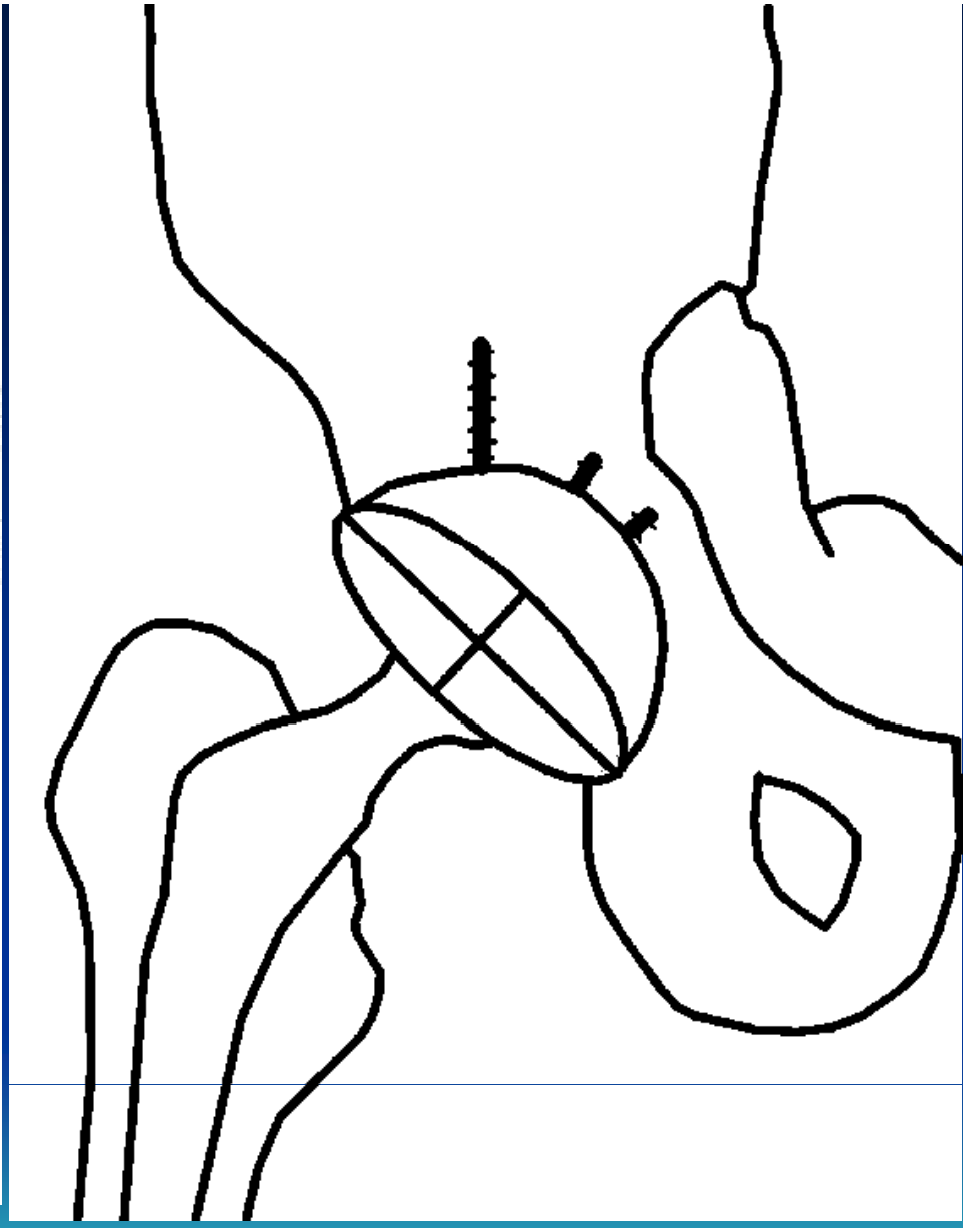
Operative Anteversion, Flexion



Radiographic Anteversion

- Easy to measure from plain radiograph
- Radiographic anteversion angle = $\sin^{-1}$ (short axis of the ellipse / long axis of the ellipse)
- By Lewinnek, *J Bone Joint Surg [Am]* ,1978;60-A:217-20.

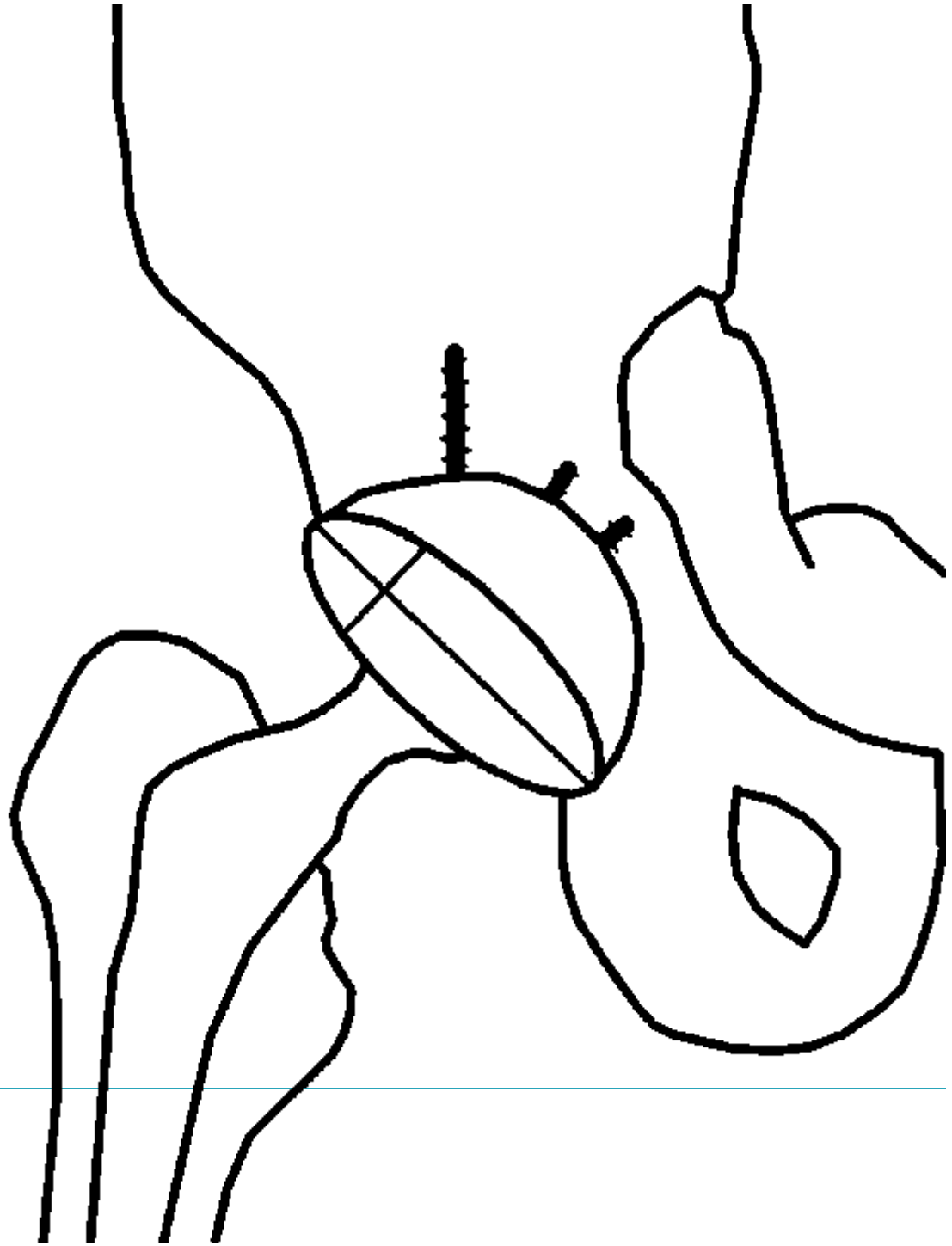




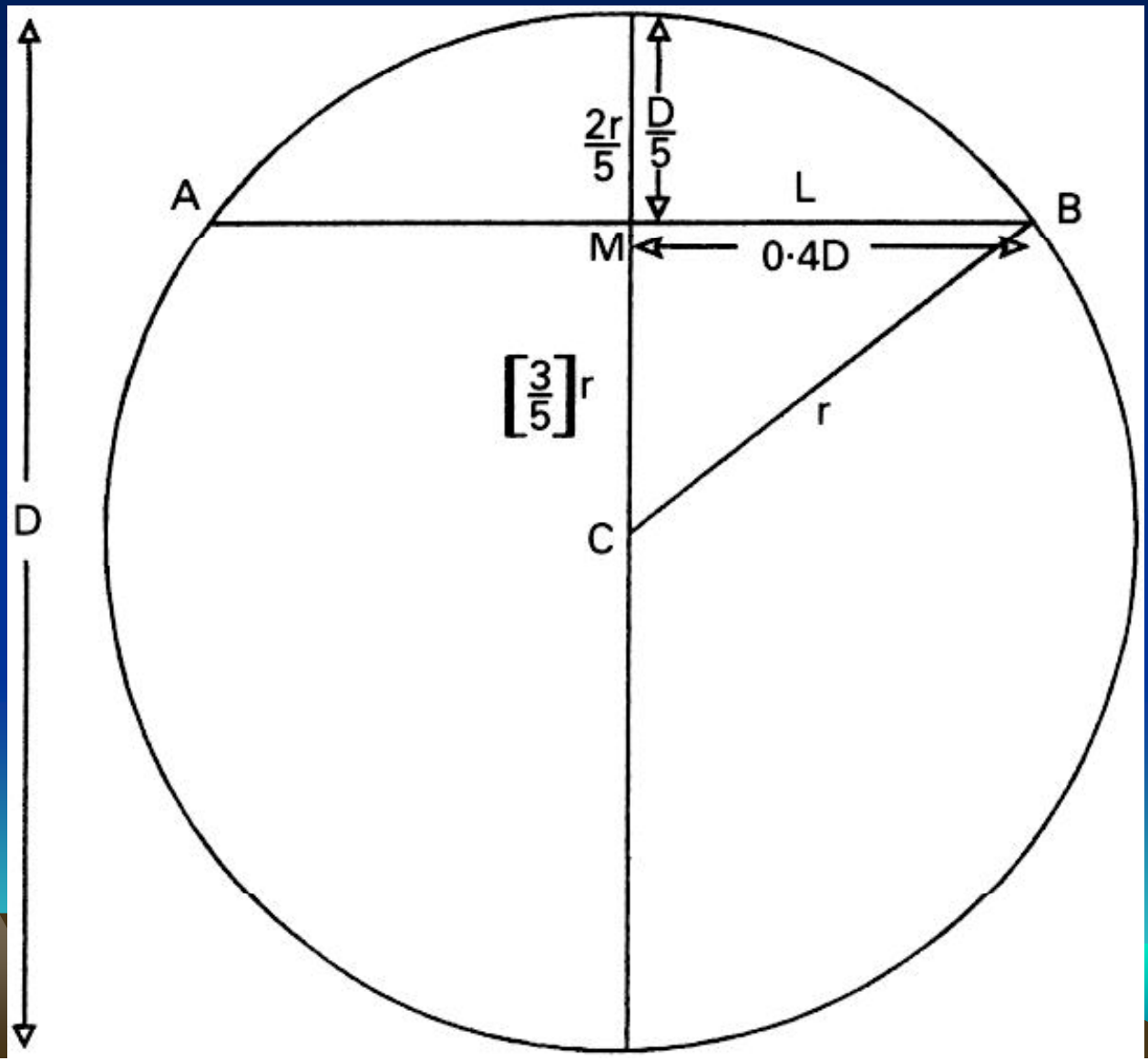
$\alpha = \sin^{-1}$ (short axis of the ellipse / long axis of the ellipse)

Another Method

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



Pradhan's Method

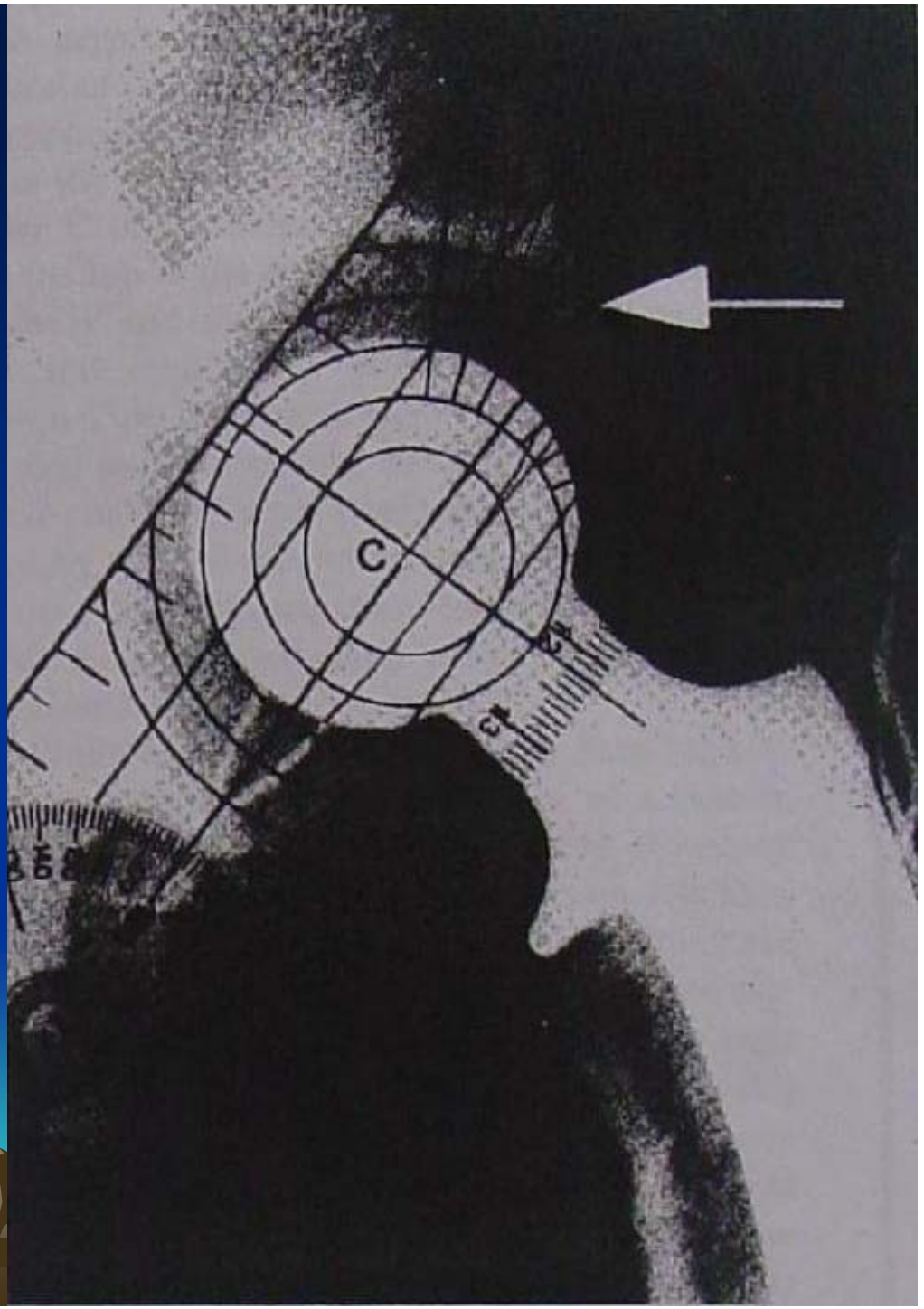


Pradhan's Method

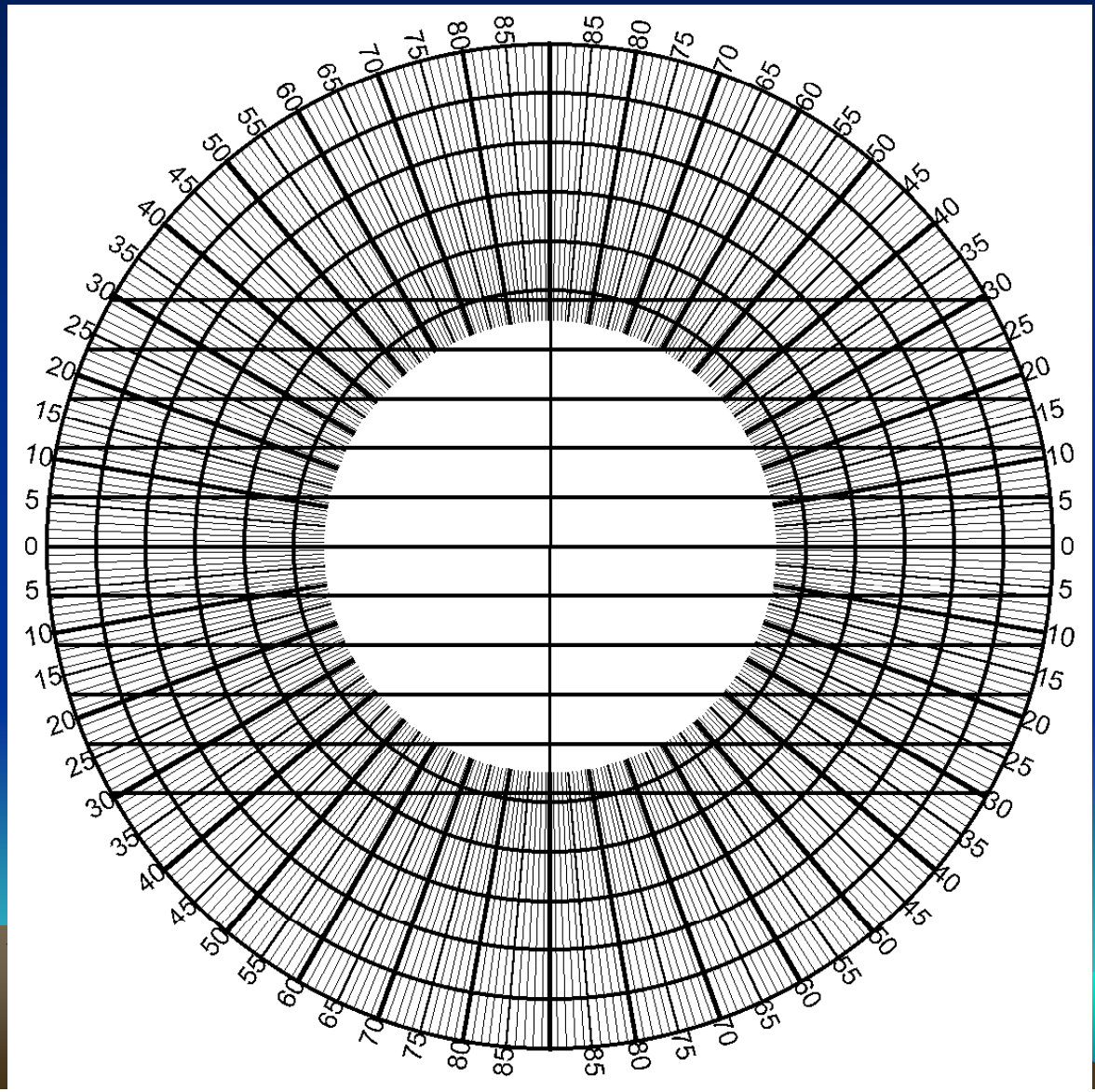
- $\alpha = \sin^{-1}(0.4D$ / long axis of the ellipse)
- *D*: the short axis at $0.4r$

Fabeck's Method

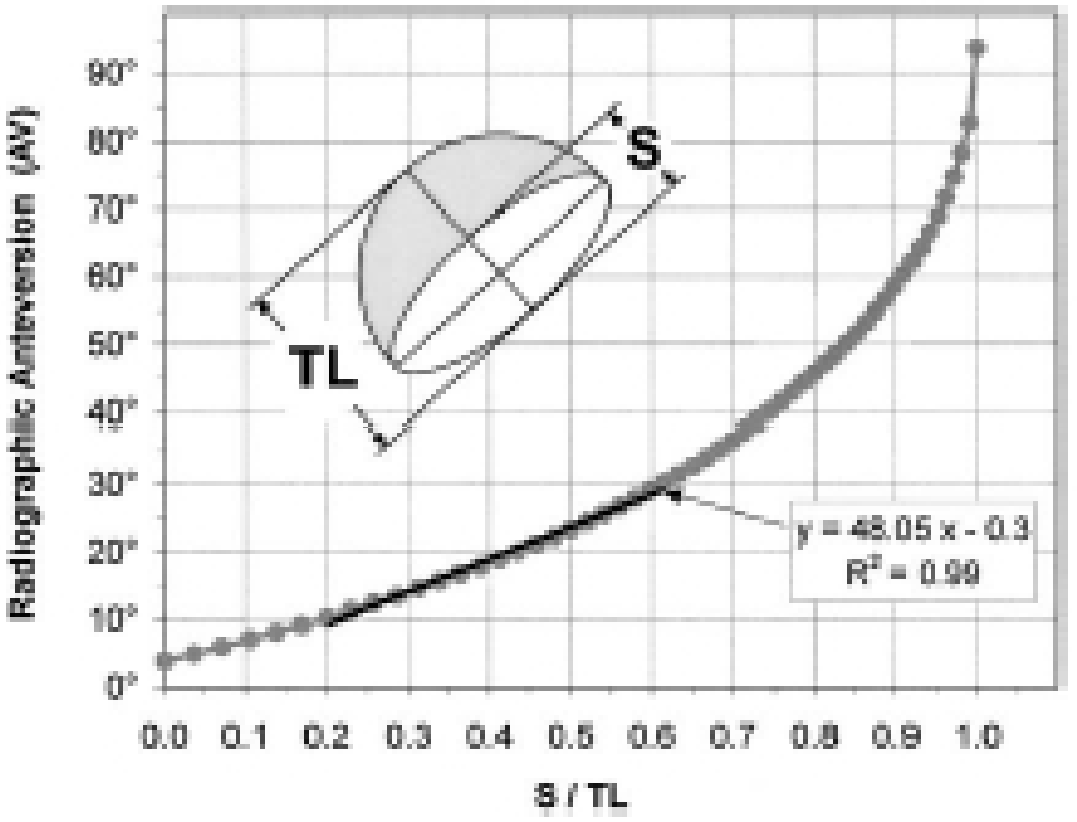
- A method to measure acetabulum cup anteversion after total hip replacement. *Acta Orthop Belg*. 1999;65:485–491.



Fabeck's method

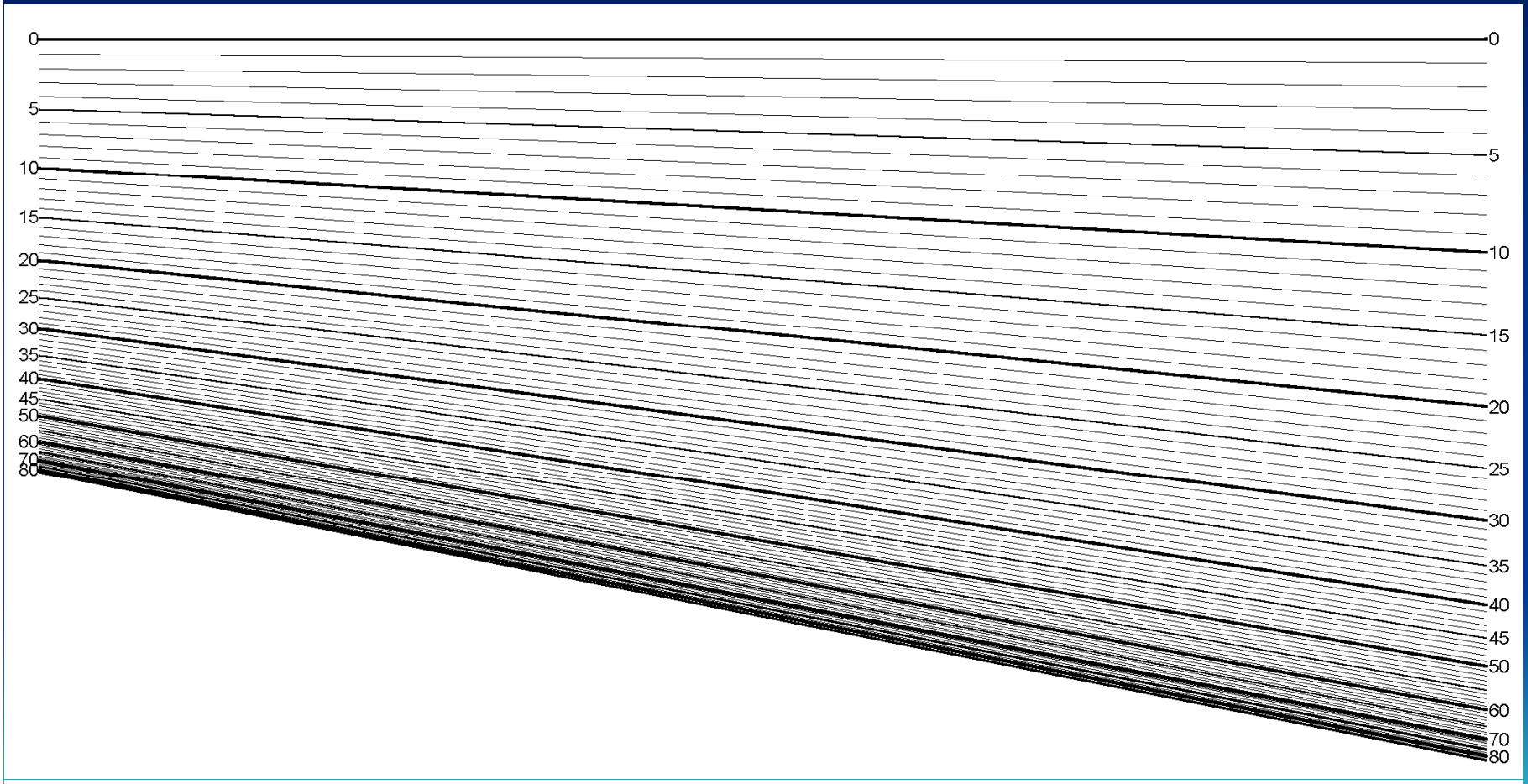


Widmer's Method

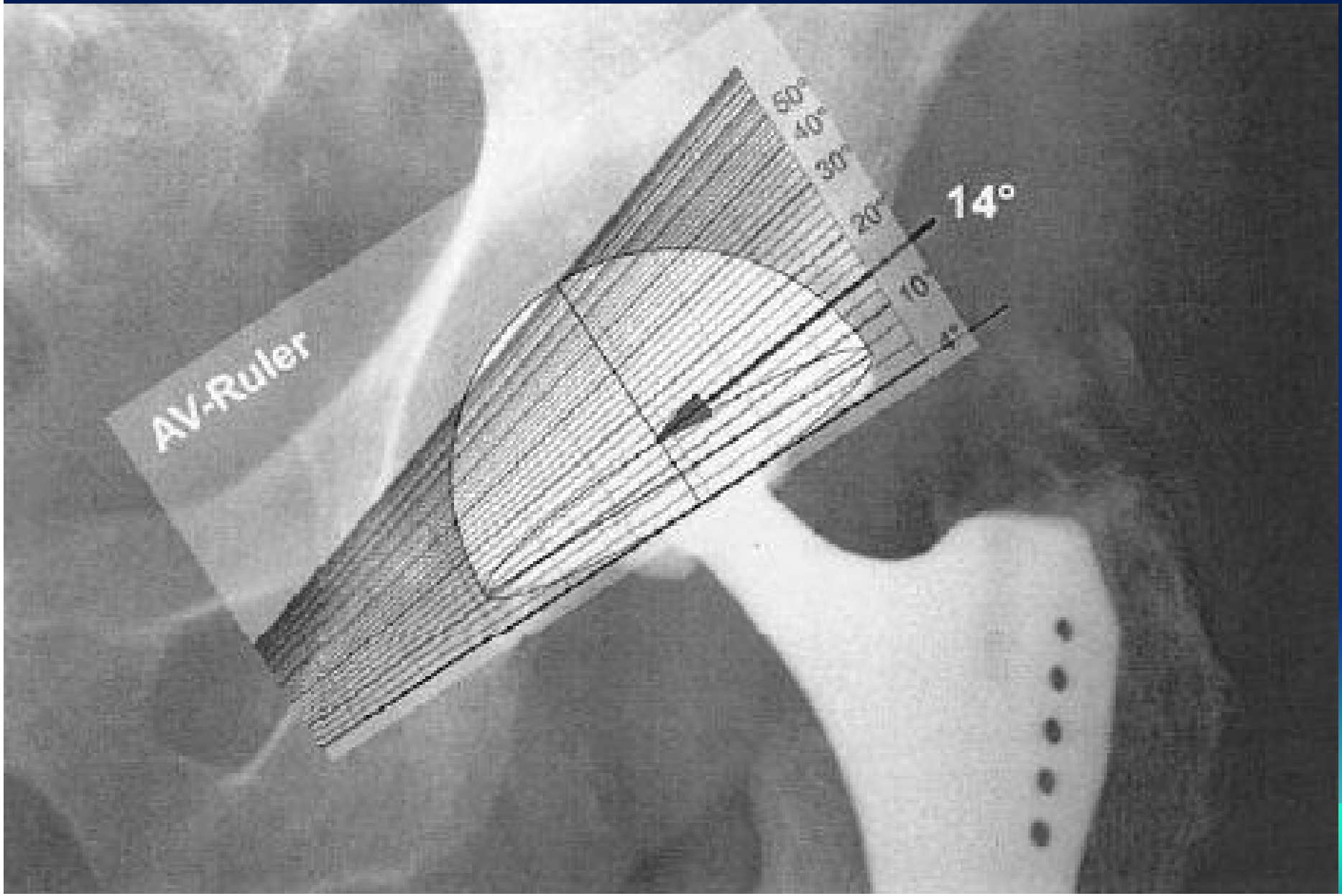


- A simplified method to determine acetabular cup anteversion from plain radiographs.
- *J Arthroplasty*. 2004;19:387–390.

Widmer's Method



Widmer's Method

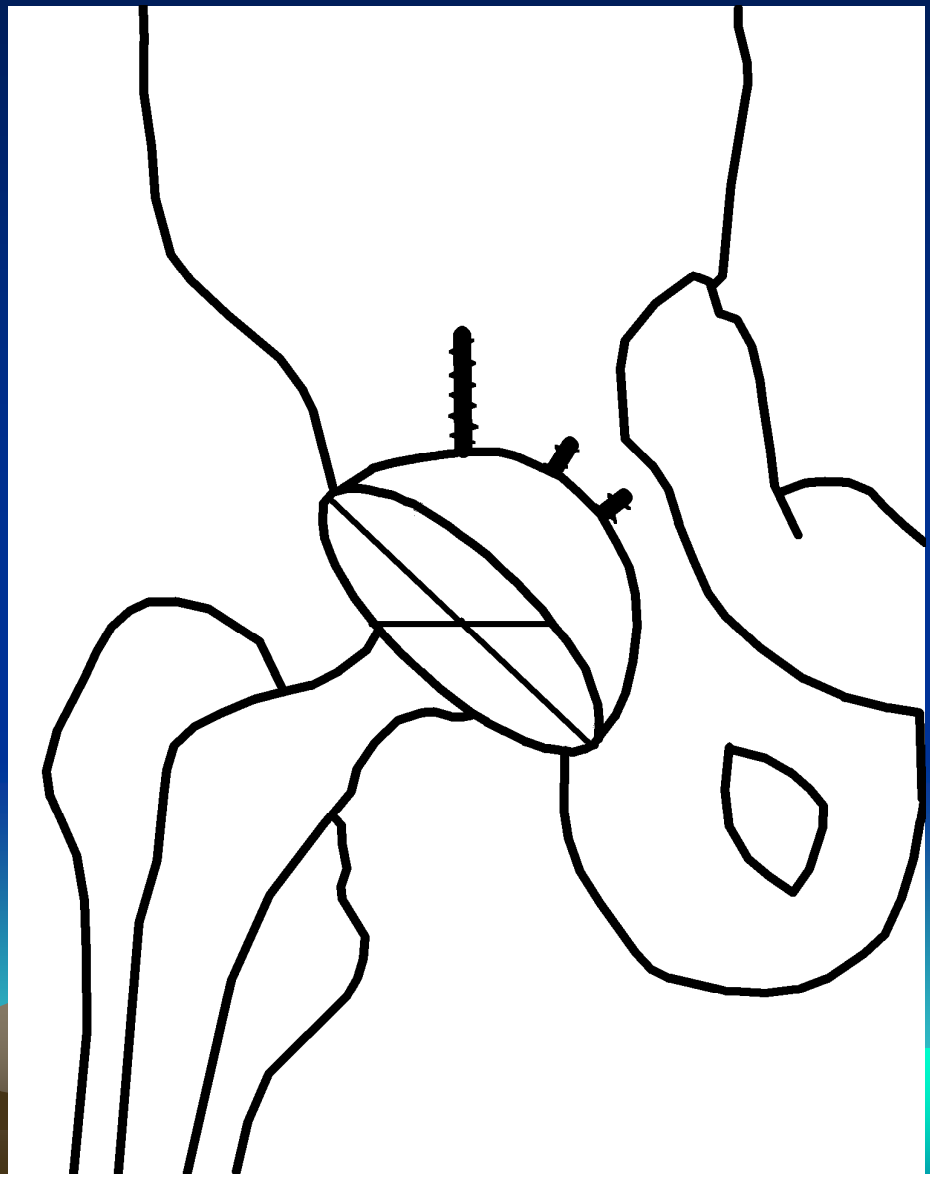


Anatomical Anteversion (True Anteversion)

- Indirect method
  - Measure radiographic anteversion, and inclination
  - Then calculate anatomical anteversion
  - anatomical anteversion = $\tan^{-1}(\tan\alpha \csc\gamma)$
  - α: radiographic anteversion
  - γ: inclination

Anatomical Anteversion

- Direct method
- McLaren's method
- anatomical anteversion $= \sin^{-1}(s_t / l_t)$



Anatomical Anteversion Direct Method

- Fabeck's method

CT Method

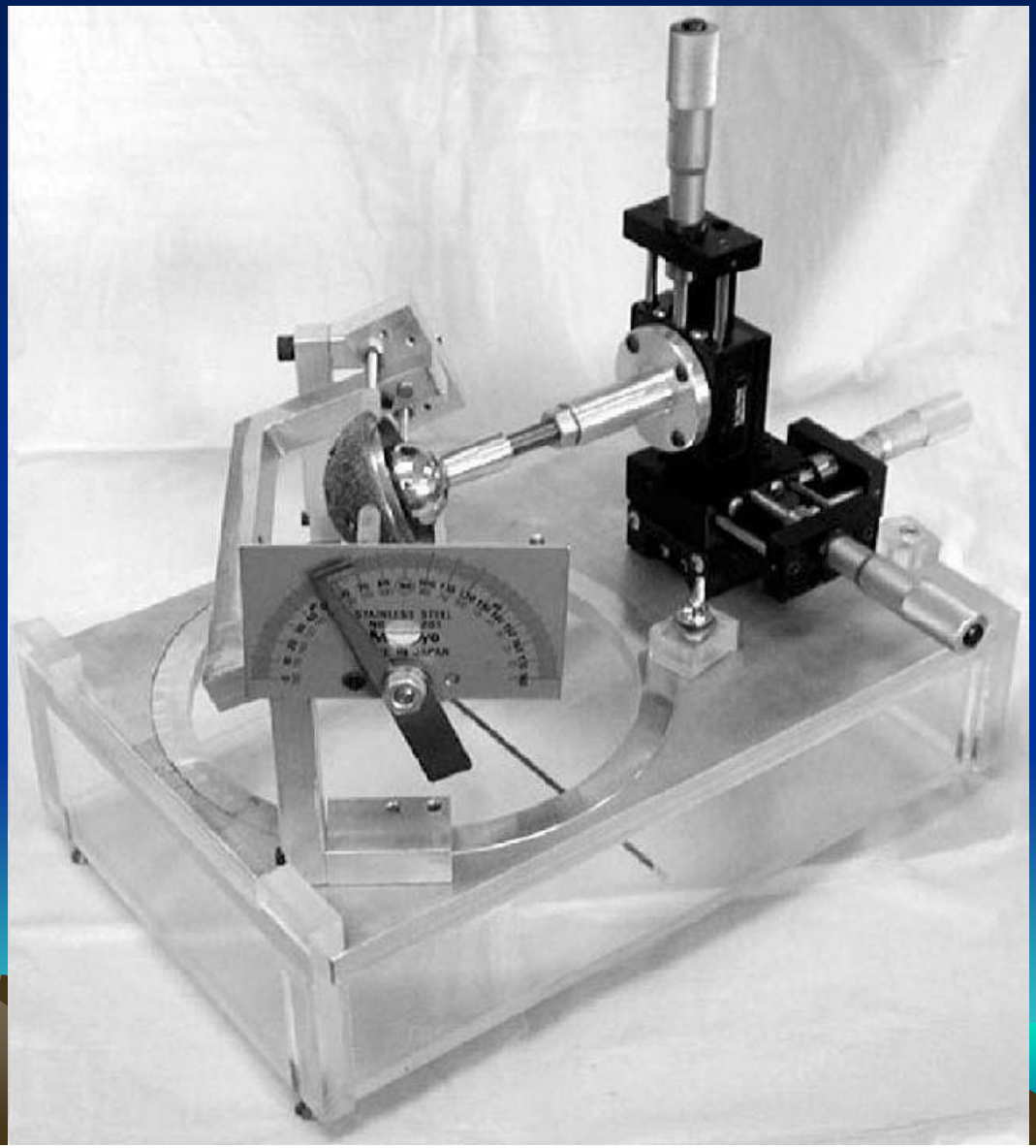

What did we do before?
What's new?
Our method (cont.)
– Find center from the 200 detected edges
The center of the 40 edges are found by calculus. Then the program will exclude the extremes and find center again and again, until there are no extremes.
– Project 240 lines from the new center with 270 degrees span. The left lower part is excluded.
– Find head edges with the same vector edge detector.
– Find the head center
– There is no exclusion criteria o digitalization.
– Results classification :
• Wrong detection on cross-correlation
• Wrong detection of acetabul
• Wrong detection of head
• Minor error on acetabular ce estimation
• Minor error on head center estimation
• Unmeasurable X-ray by Livermore's method
• Partially measurable X-ray, which can be measured by oth ethod
Results
data
Our program can detec 61 of 64 simulated X-rays without misdetection (fig.6).
-The three mis-detected

The Digitalized Simulator

The Digitalized Simulator

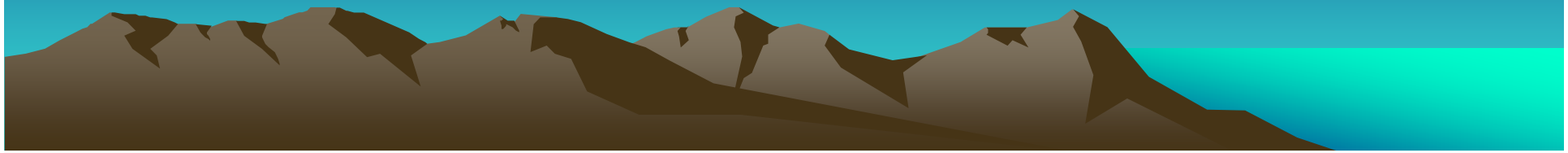
- Before developing measuring methods, we must develop the “gold standard”.
- Mechanical device is straightforward but expensive and having an unpredicted precision.
- The method using mechanical simulator requires taking radiograph and then transforming to digital form.
- It takes many processes and every process may cause error thus interferes with the final precision.

The Mechanical Simulator



The Digitalized Simulator

- Many published methods used Fourier transformation.
  - Speed
  - Precision?
- Ray tracing
- Transform thickness to grey scale



Algorithm

- Build mathematical model of acetabulum with femoral head.
- Ray tracing every projected pixel on virtual film.
  - Calculate metal thickness where the X-ray beam passes.
  - Transform thickness to grey scale.
  - Draw in the virtual film.

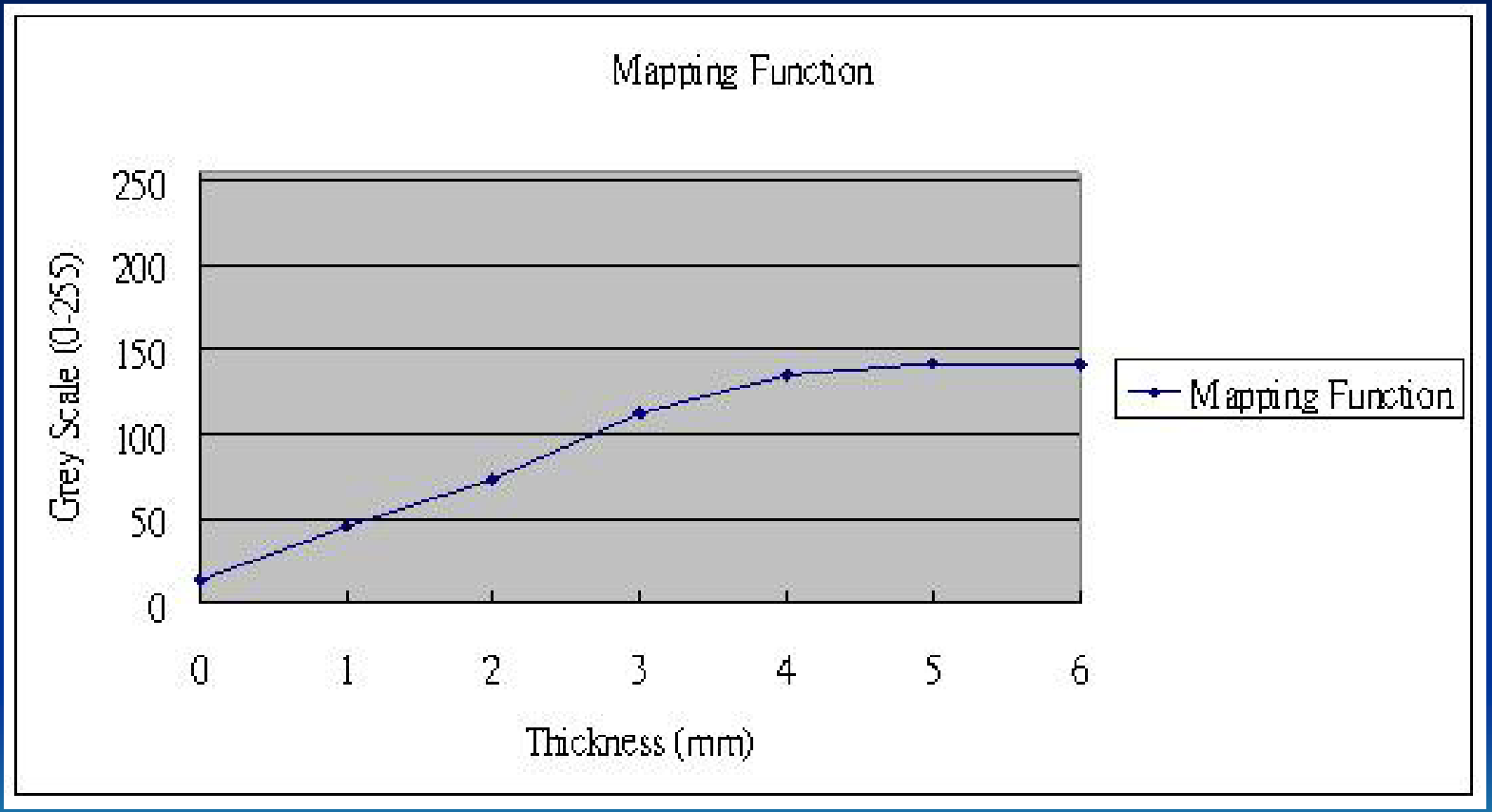
Transforming Thickness to Grey Scale

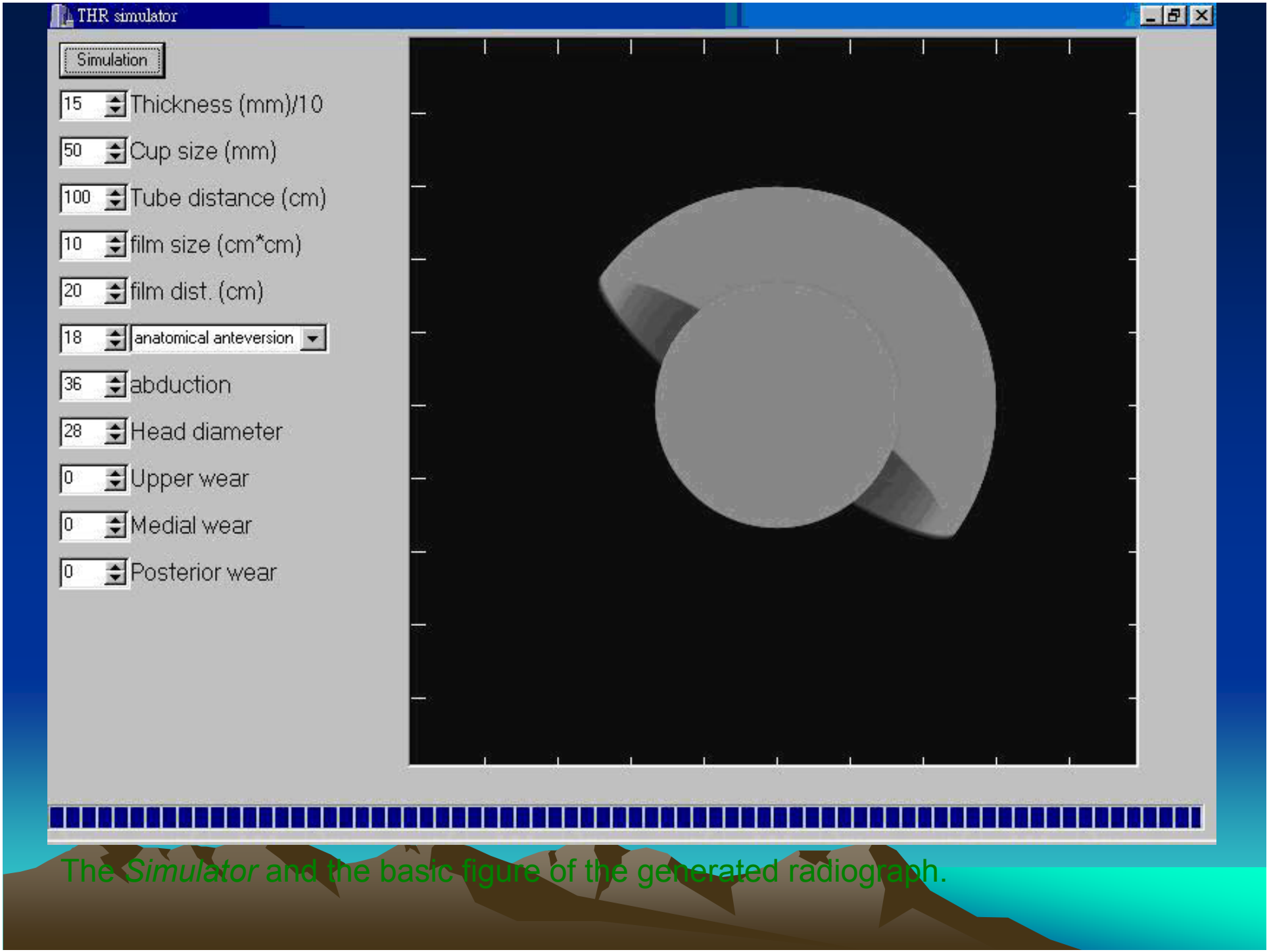
- Beer-Lambert law.
  - Penetration = e^{-kbc}
  - *k*: molar absorbability
  - *b*: path length
  - *c*: concentration
  - *k*: different in different materials and different radiation energy.
  - Radiation energy from X-ray tube: normal distribution
- Lookup table method

Lookup Table Method

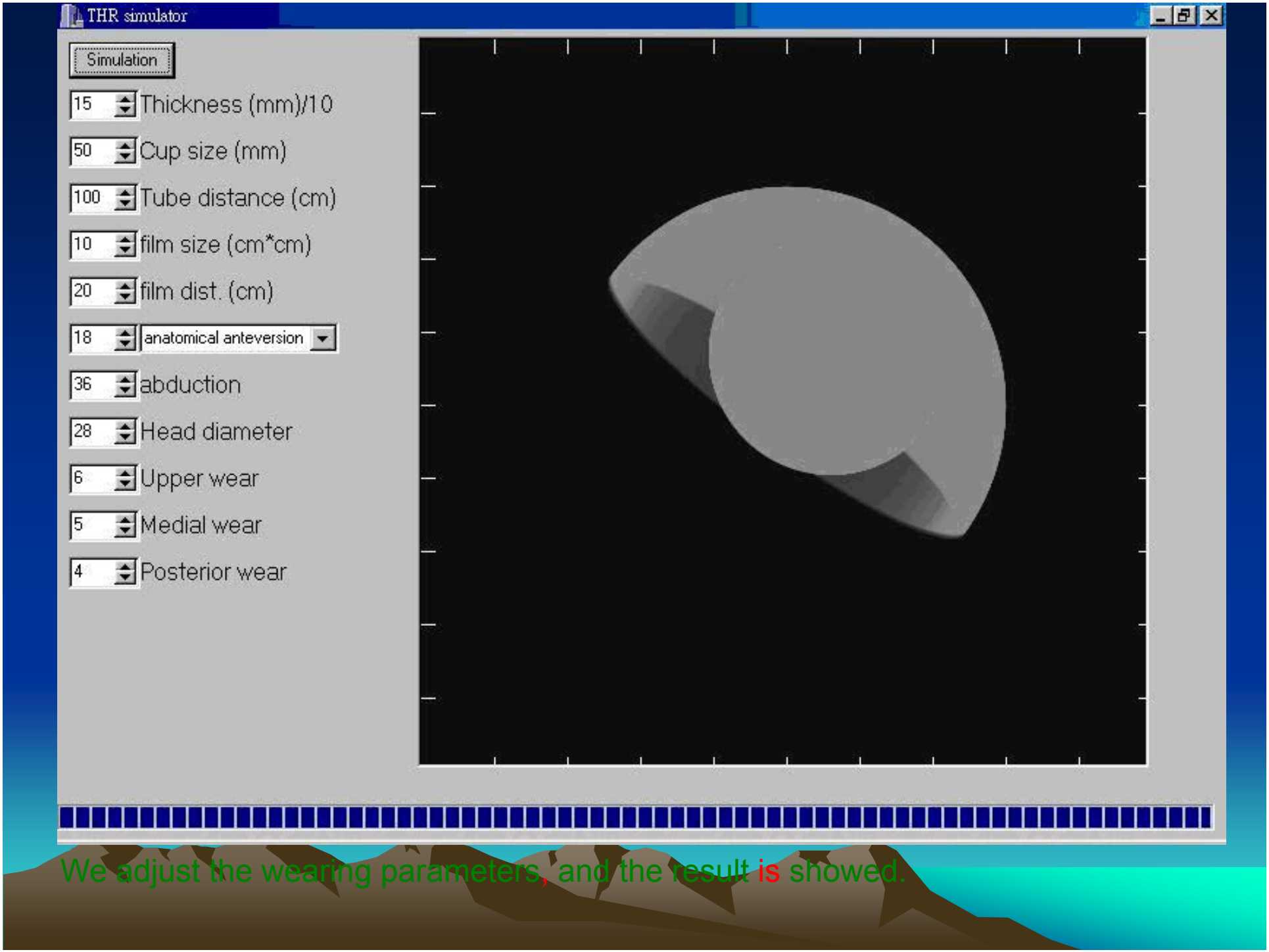
- We propose to implement the *Simulator* by lookup table method.

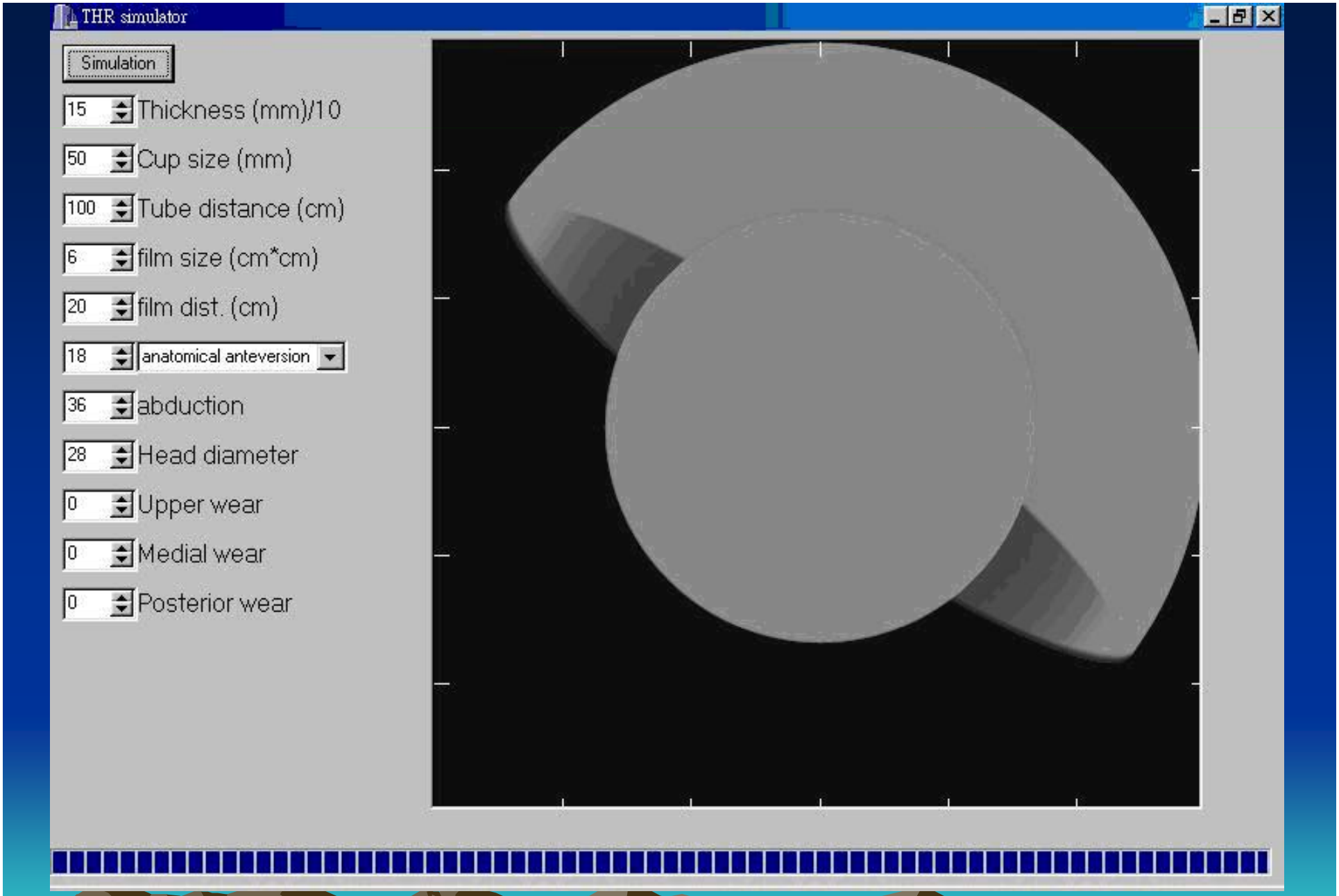
Lookup Table Method



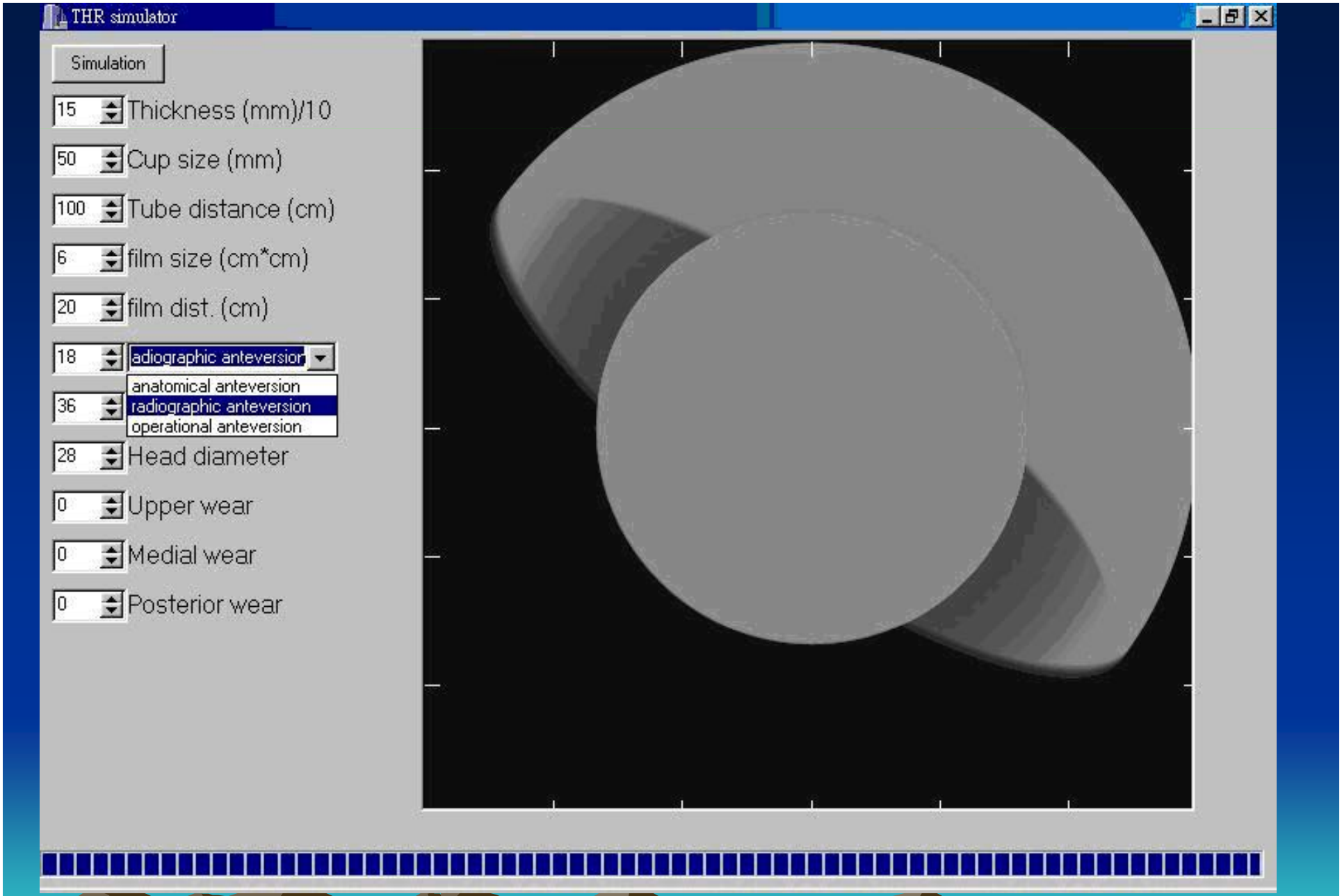


The *Simulator* and the basic figure of the generated radiograph.


THR simulator
Simulation
15 Thickness (mm)/10
50 Cup size (mm)
100 Tube distance (cm)
10 film size (cm*cm)
20 film dist. (cm)
18 anatomical anteversion
36 abduction
28 Head diameter
6 Upper wear
5 Medial wear
4 Posterior wear
We adjust the wearing parameters, and the result is showed.



We adjust the film size parameter to simulate a smaller film in the same picture, and the result is shown.



We choose the anteversion type as radiographic anteversion, and the result is shown.


8:34PM
25
Simulated Radiograph of Total Hip Arthroplasty for Verifying Measuring Instrument
Chen-Kun Liaw[1,3] Rong-Sen Yang[2] Sheng-Mou Hou[2] Chiou-Shann Fuh[3] Tai-Yin Wu[4]
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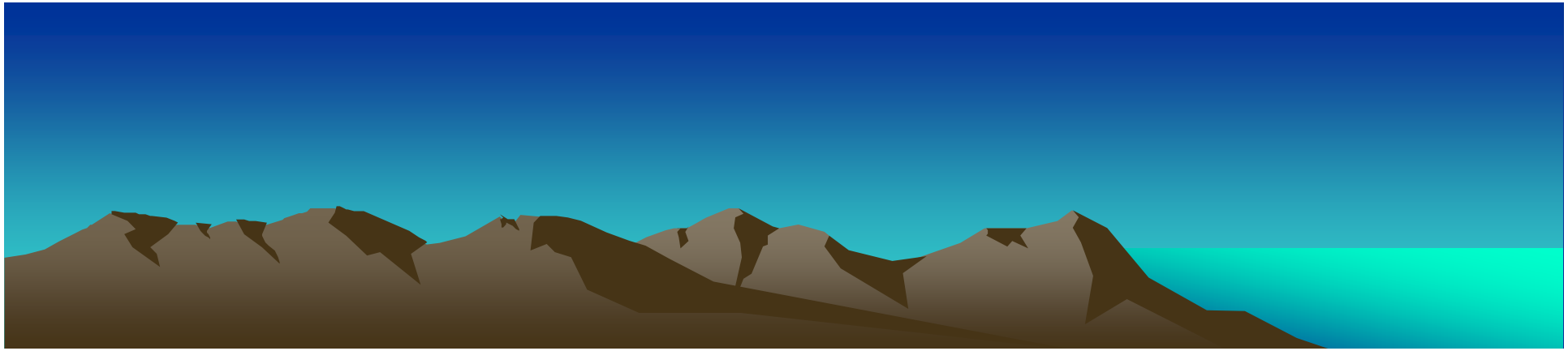
National Taiwan University Hospital, Taipei, Taiwan[2]
National Taiwan University, Computer Science and Information Engineering[3]
Taipei City Hospital[4]
Abstract
Introduction
Many parameters can (should) be measured.
a. Orientations:
Anteversion:
Lewinnek method
Liaw method
Widmer method
Fabeck method
Inclination
b. Wearing: Upper, Medial, Posterior
Manual method
Livermore method
...
Computerized method
Hardinge method
Shaver method
Liaw method
Verification of these methods is important!!
Mechanical Simulation
Advantages:
1.Easy to persuade people to use.
Disadvantages
1.Expensive
2.Precision?
3.Digitalization
Our Solution
•Building our own software
•Cost down
•Digitalization
•Bias elimination
•Batch processing can automatically produce many simulated X-rays.
Our Algorithm
•Ray tracing
-See X-ray as many X-ray lines
-Trace every X-ray line
-Calculate the total thickness of metal it passes.
-Convert thickness to gray-scale pixel

New Protractor of Measuring Orientations after Total Hip Arthroplasty

CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 451, pp. 134–139

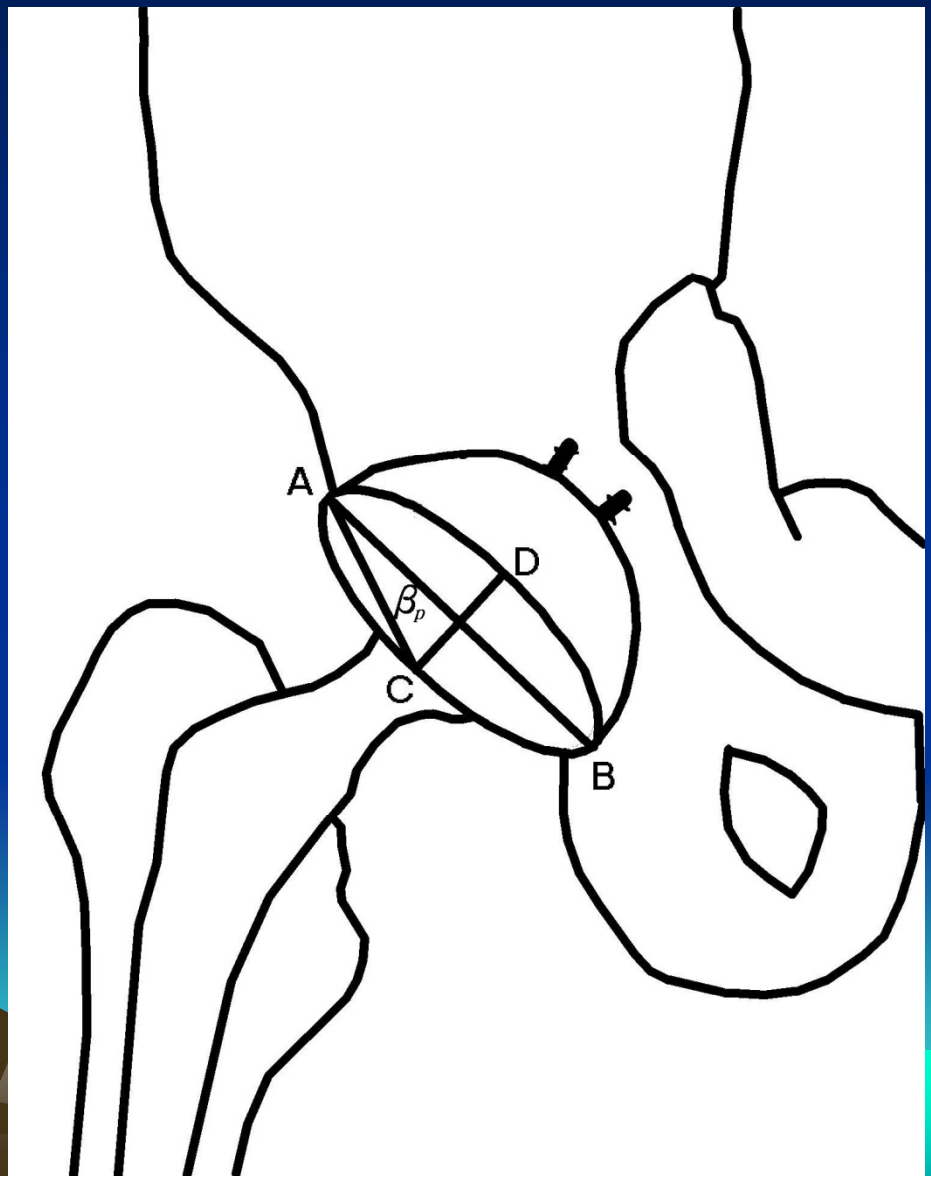
A New Tool for Measuring Cup Orientation in Total Hip Arthroplasties from Plain Radiographs

Chen-Kun Liaw, MD; Sheng-Mou Hou, MD, PhD, MPH; Rong-Sen Yang, MD, PhD; Tai-Yin Wu, MD; and Chiou-Shann Fuh, PhD

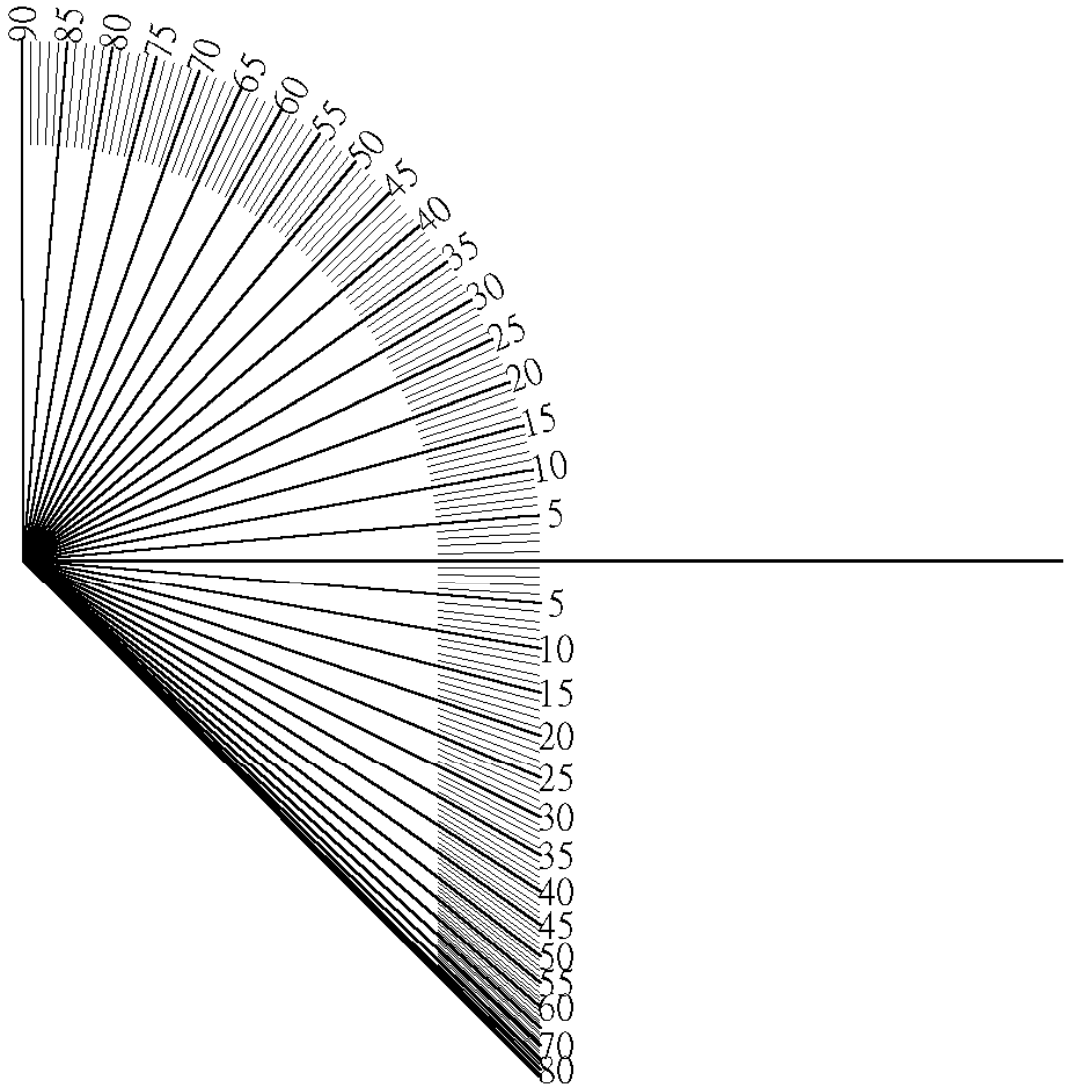


Our Method

- $\alpha_p = \sin^{-1} \tan \beta_p$



Our Method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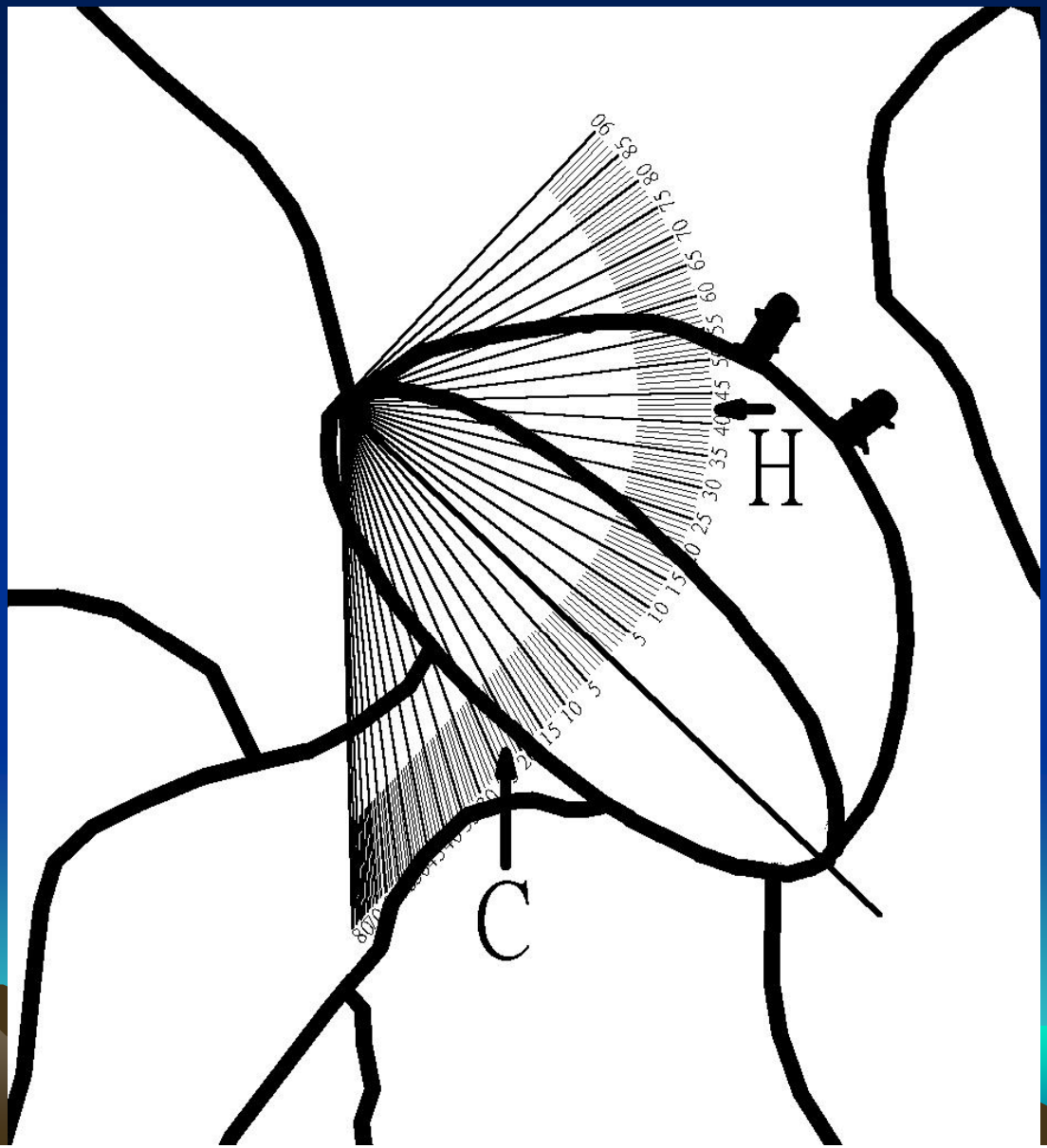
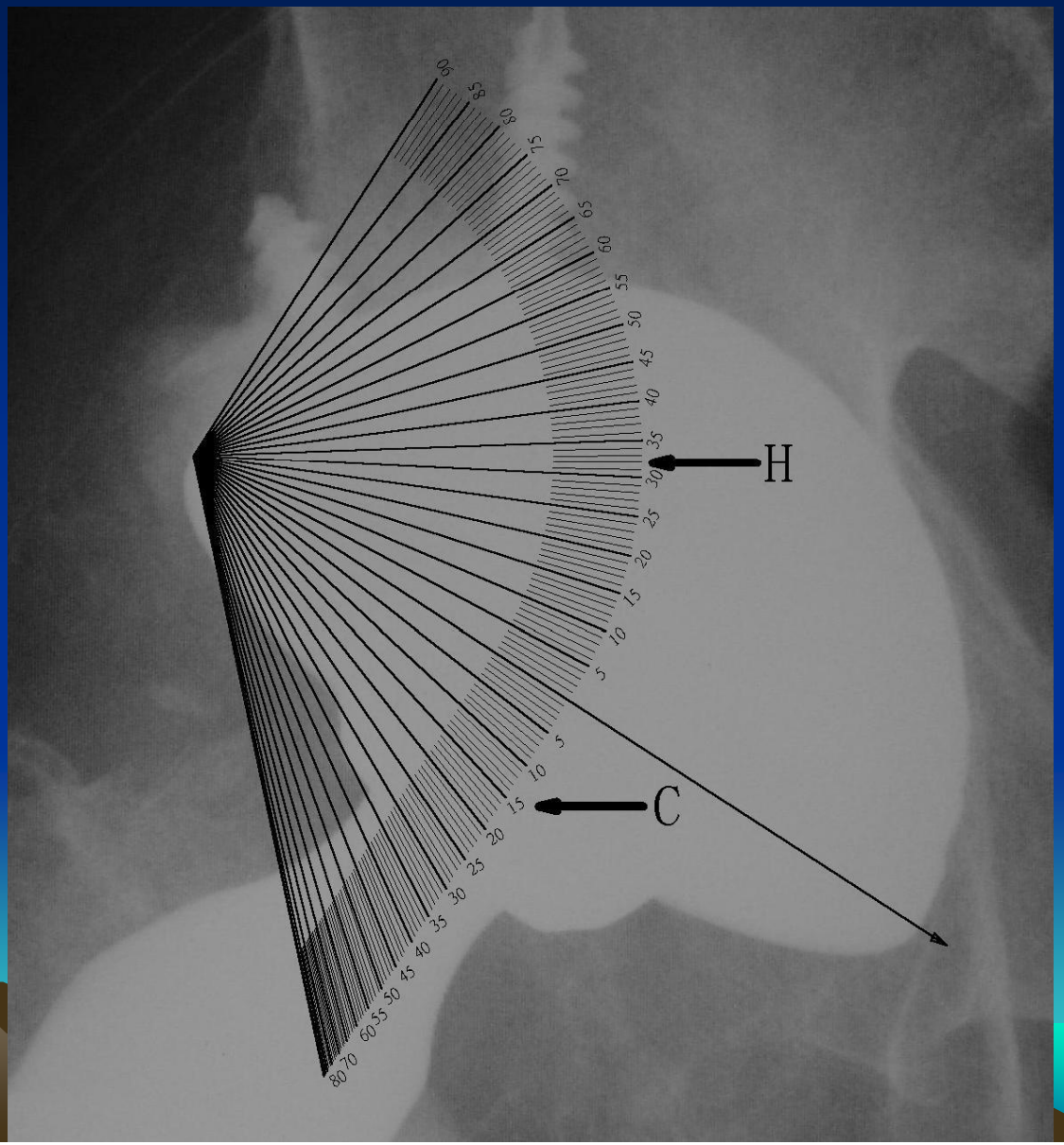
Our Method

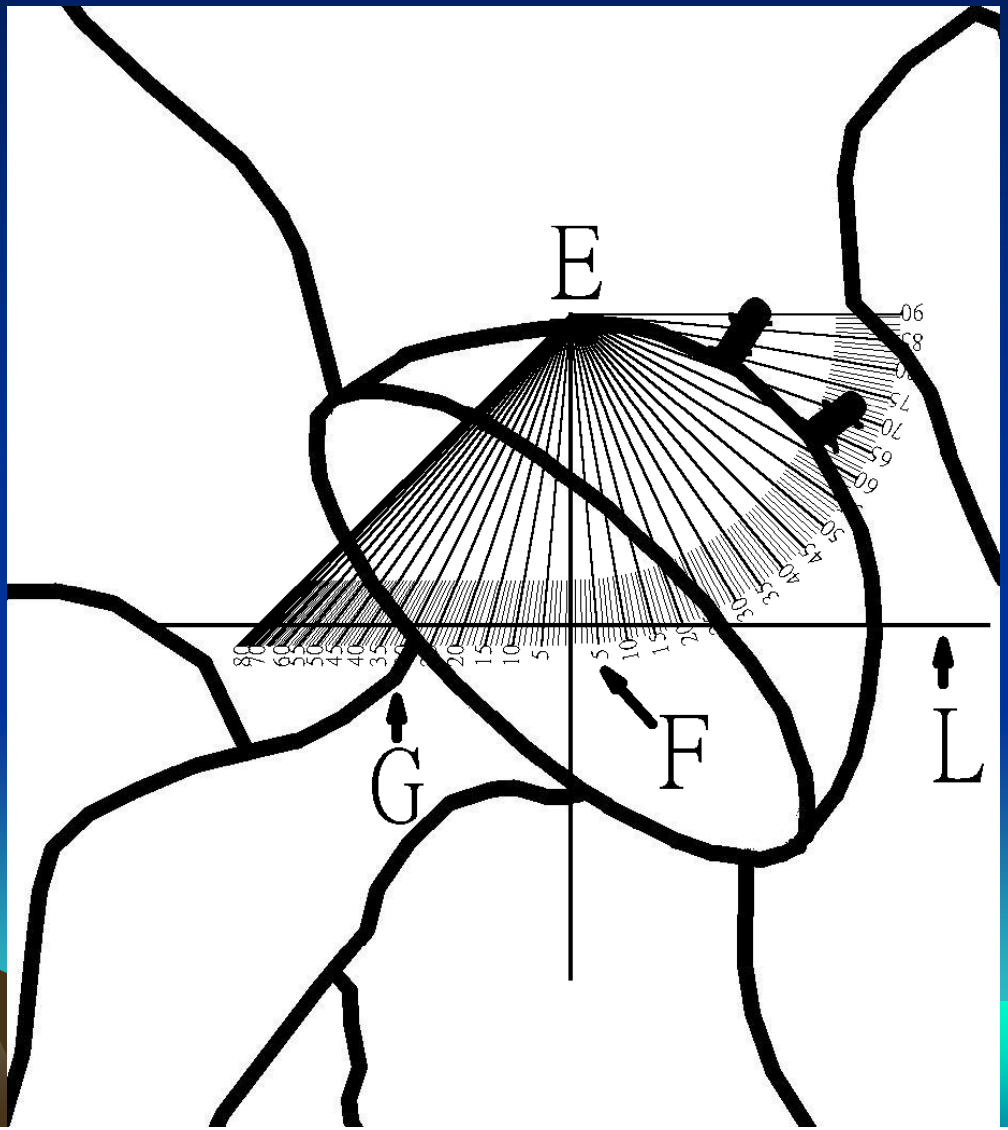


Our Method



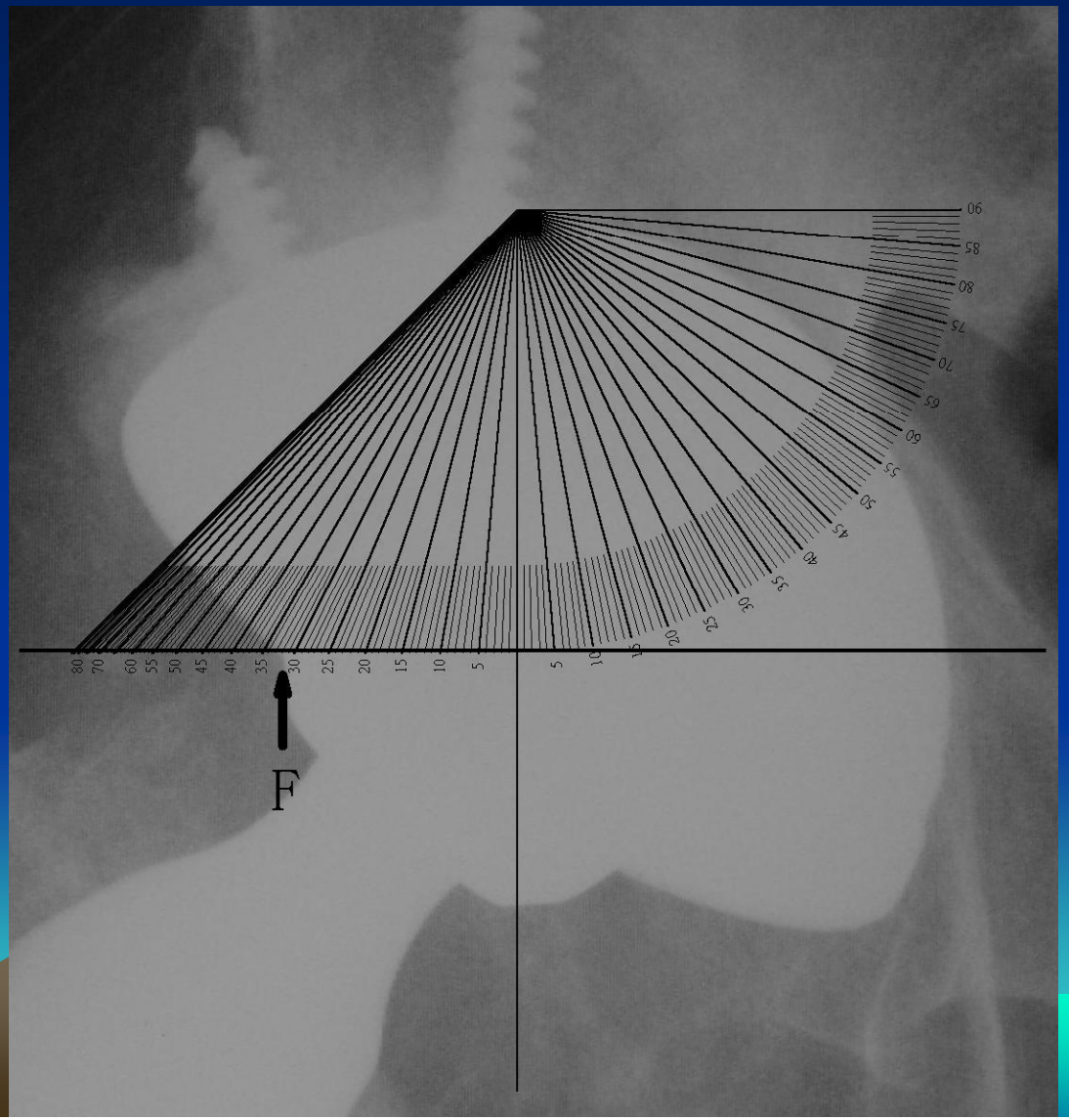
Anatomical Anteversion Direct Method

- Our method



Anatomical Anteversion Direct Method

- Our method

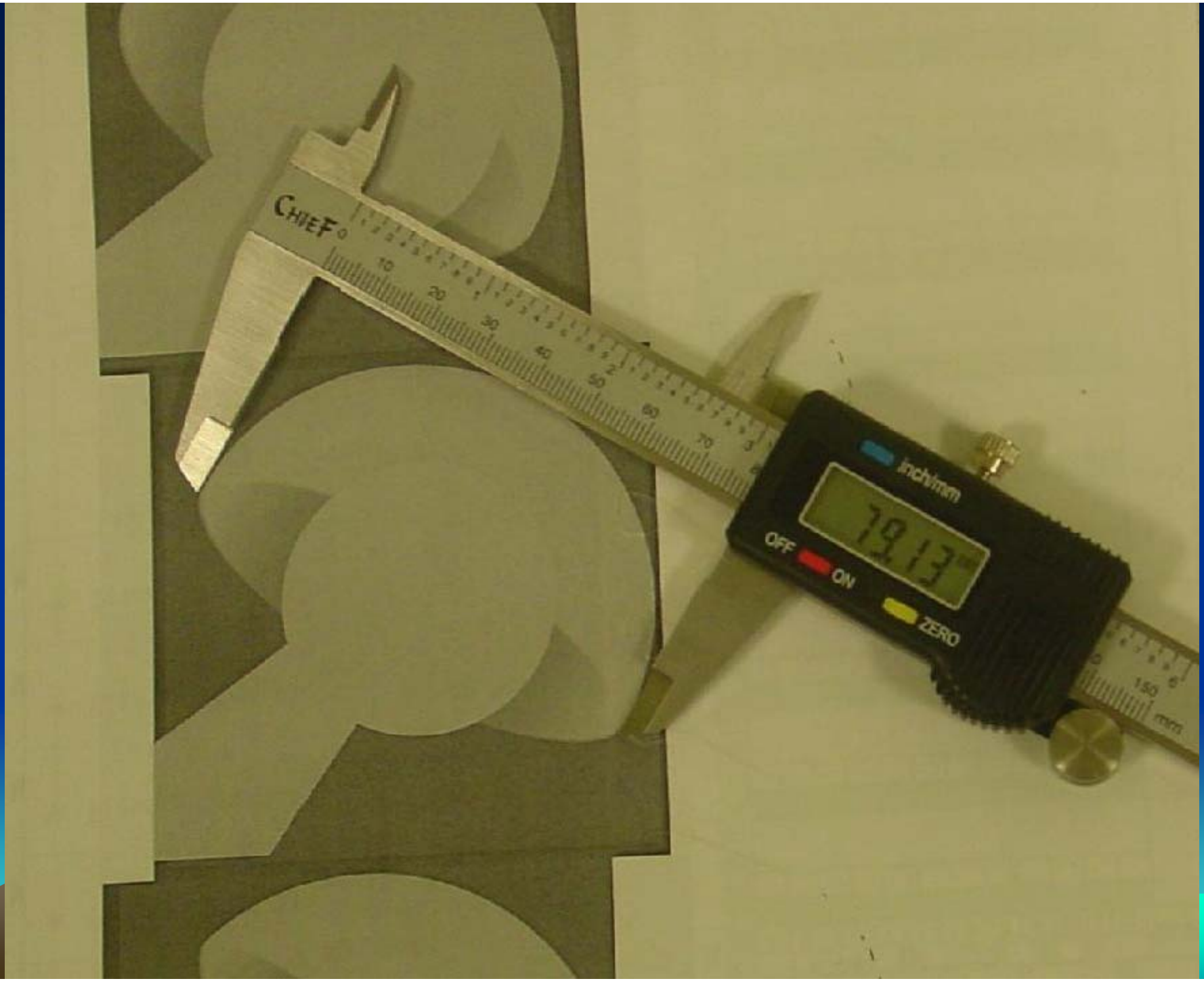


Proposed Methods

- We simulate 45 total hip arthroplasty radiographs with 15 different anteversions ranging from 15°–29° and random inclinations using our *Simulator*.
- We also collect 45 total hip arthroplasty radiographs.

Materials and Methods

- Measure the anteversion of the 90 radiographs with Lewinnek method.
- Measure the anteversion again one week later with our method.
- Compare the difference between the two measurements.


CHIEF
inch/mm
OFF
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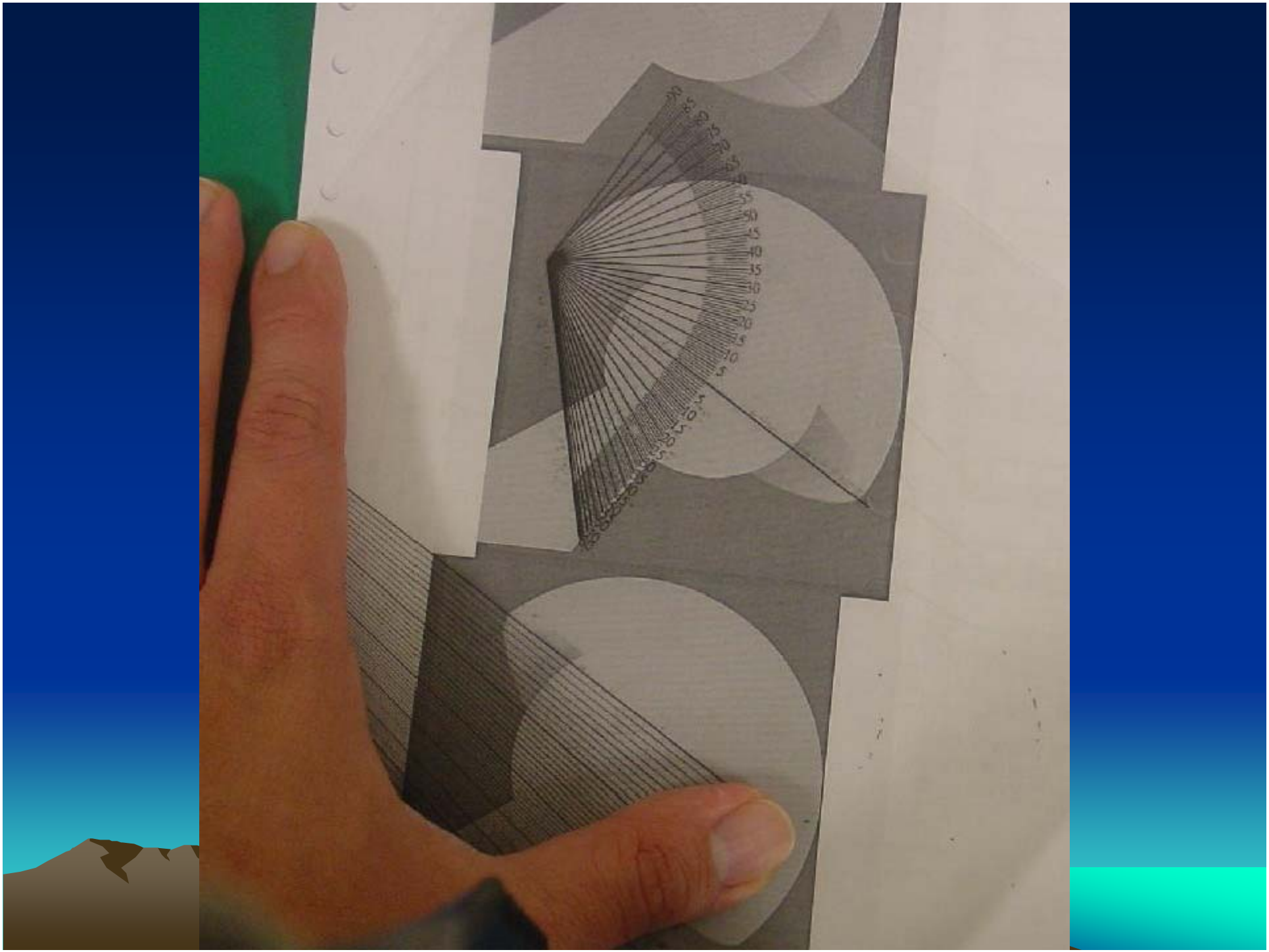

Results

- For simulated radiographs
- Max error:
  - Liaw: 3°
  - Lewinnek: 2.61°
- Median error:
  - Liaw: 1°
  - Lewinnek: 1.23°
- Mean error:
  - Liaw: 0.96°
  - Lewinnek: 1.2°
- No statistical difference between the two methods

Results

- For real radiographs
- Difference between our and Lewinnek's methods
  - Mean of absolute difference: 1.34°
  - Standard deviation of absolute difference: 1.13°

Discussion

- Perfect position required to get the real anteversion.
- Pradhan's data
  - Mean error was 0.88°.
  - Standard deviation of error was 0.65°.

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A New Tool for Measuring Cup Orientation in Total Hip Arthroplasty

Chen-Kun Liaw[1,3] Rong-Sen Yang[2] Sheng-Mou Hou[2]
Chiou-Shann Fuh[3] Tai-Yin Wu[4]
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Taipei City Hospital[4]

Abstract

[Background] the measuring of the acetabulum prosthesis orientation is important especially for minimal invasive hip Arthroplasty. The orientation of acetabulum consists of two parameters: the abduction (inclination) and anteversion angles. Anteversion can be further subdivided into true and planar anteversion. We have developed a new protractor to measure the orientation of the cup in total hip arthroplasty. With this new device, we can measure the true and planar anteversion as well as abduction. No other instruments such as a calculator or special table are needed, but a good quality antero-posterior Roentgenogram is required.

[Methods] We use "THR simulator" to simulate the acetabulum and femoral head x-rays, and simulate 45 THR radiographs with 15 different anteversions ranging from 15°~29° and 45 real THR radiographs. Two orthopaedic specialists using Lewinnek's and our methods to measure the anteversion and abduction angles of these X-rays. Then we compare the two results with pair *t* test.

[Results] The mean errors are 0.96° with our method and 1.2° with the method of Lewinnek et al. There is no statistical difference between the two methods.

[Conclusions] Our new protractor allows measurement of true version, planar version, and abduction. However, further studies are needed to provide a gold standard for measurement.

Introduction

Lewinnek method

measure long axis: *l*

measure short axis: *s*

anteversion= arc sin(*s*/*l*)

Our Method

Our protractor is derived from trigonometrical method.

This protractor can be used to measure anatomical anteversion (true anteversion) and radiographic anteversion (planar anteversion).

Measuring radiographic anteversion (planar anteversion)

Measuring anatomical anteversion (true anteversion)

25 8:35PM

The Improvement of Widmer's Protractor

The Journal of Arthroplasty Vol. 00 No. 0 December 2007

Measurement of the Acetabular Cup Anteversion on the Simulated Radiographs

Chen-Kun Liaw, MD, PhD,*,†,[1] Rong-Sen Yang, MD, PhD,‡,[1]
Sheng-Mou Hou, MD, PhD, MPH,‡ Tai-Yin Wu, MD,§ and Chiou-Shann Fuh, PhD†

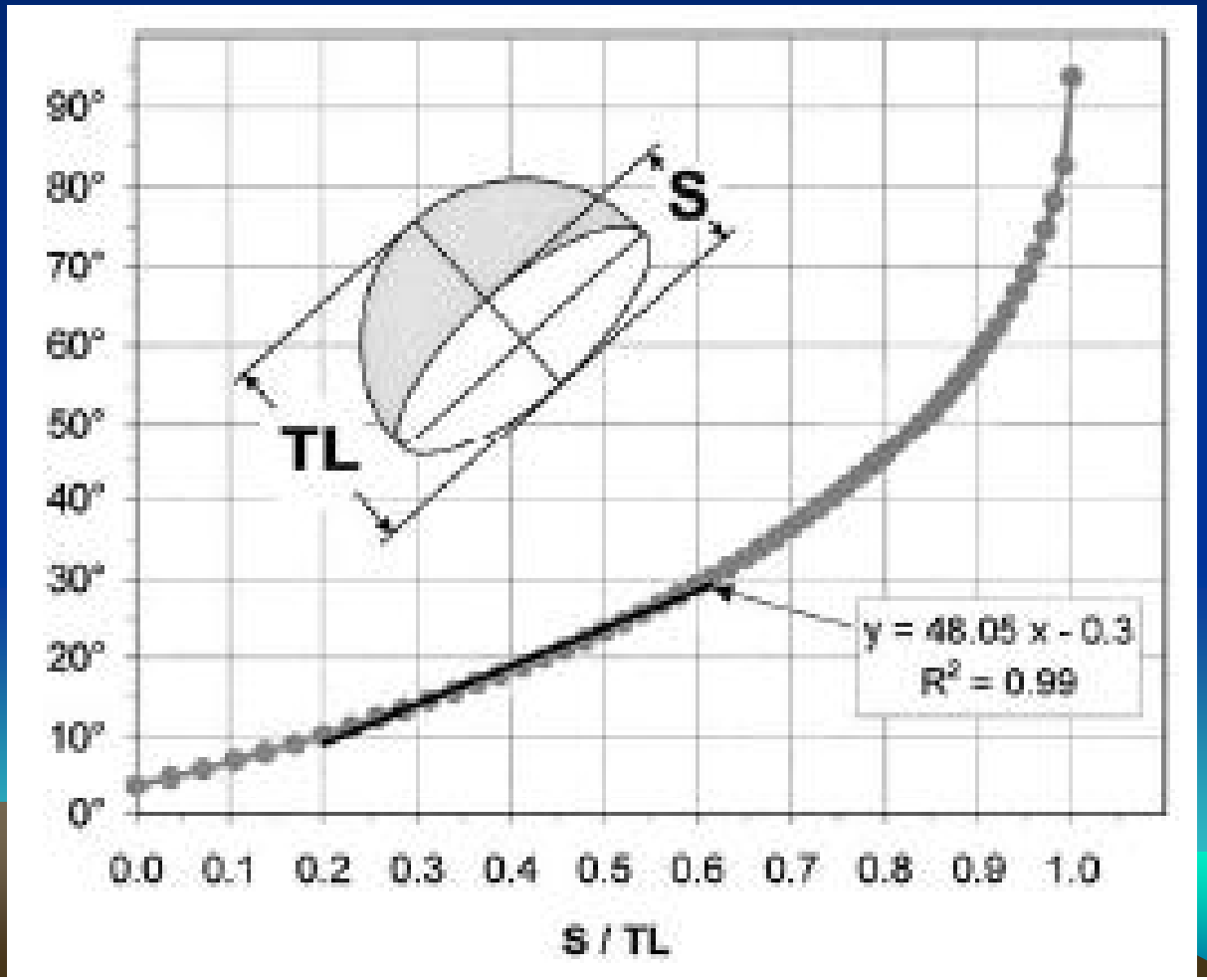
Widmer's Method

- Easy to use, but imprecise.

- Widmer, K.H., A simplified method to determine acetabular cup anteversion from plain radiographs. *J Arthroplasty*, 2004. **19**(3): p. 387-90.

Widmer's Method

- Anteversion= 48.5*(*S*/*TL*)-0.3



Sources of Imprecision

- Approximate curve with linear regression.
- Ignore different inclination (abduction) influences on anteversion of oblique projection.

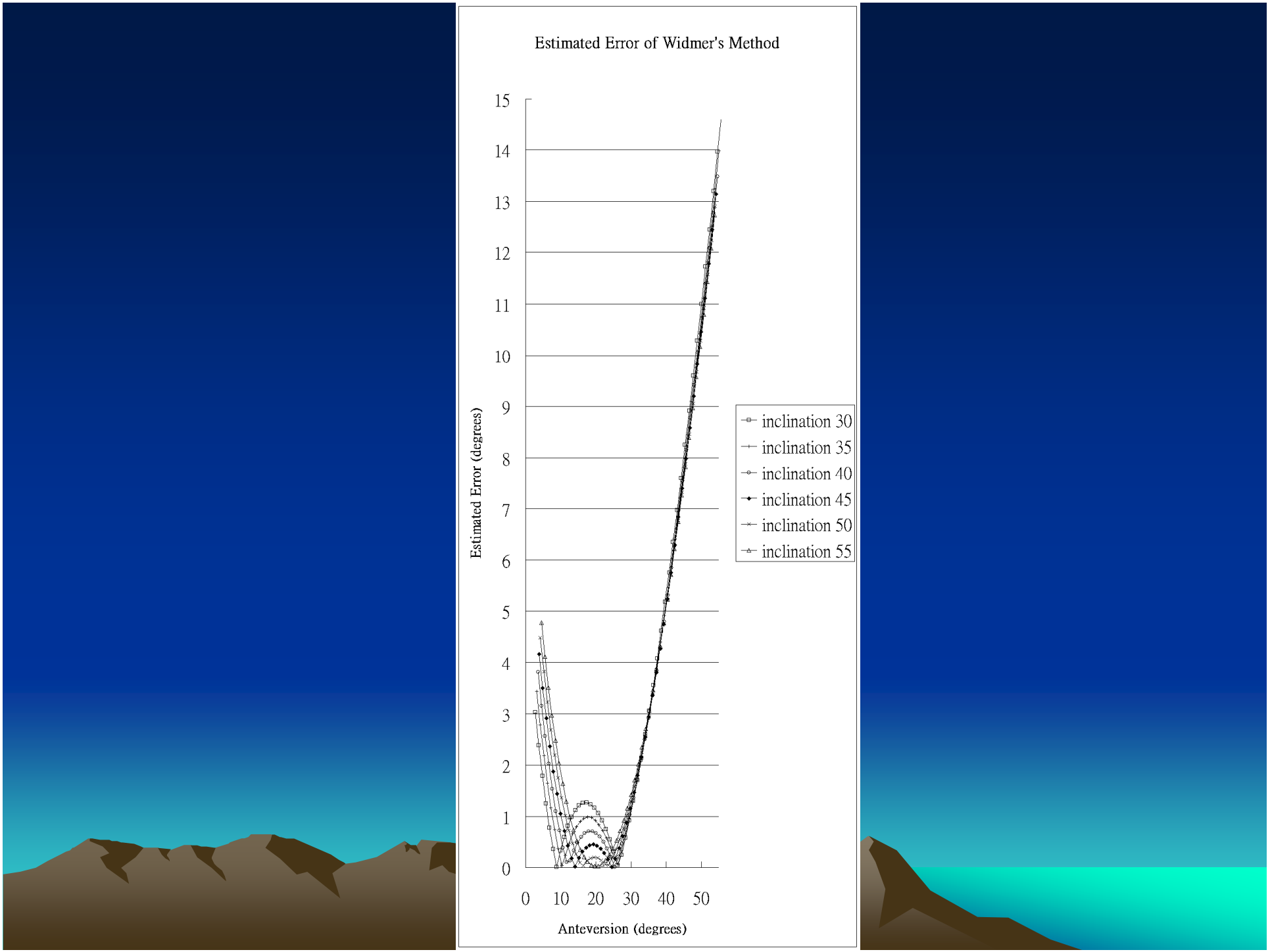
Proposed Methods

- Improve precision
- Use hip AP view radiographs
  - Eliminate second source of imprecision.
- Approximate curve with mathematic equation.

Mathematical Relationship

- $TL=(I+S)/2$
- $TL= S/(S/TL_{ratio})$
- $I= 2\,TL- S = 2\,S/(S/TL_{ratio})- S$
- $S/I = S/(2\,S/(S/TL_{ratio})- S)= (S/TL_{ratio})/(2-(S/TL_{ratio}))$

- Radiographic version
  $= \sin^{-1}(S/I)$
  $= \sin^{-1}((S/TL_{ratio})/(2-(S/TL_{ratio})))$


Estimated Error of Widmer's Method
Estimated Error (degrees)
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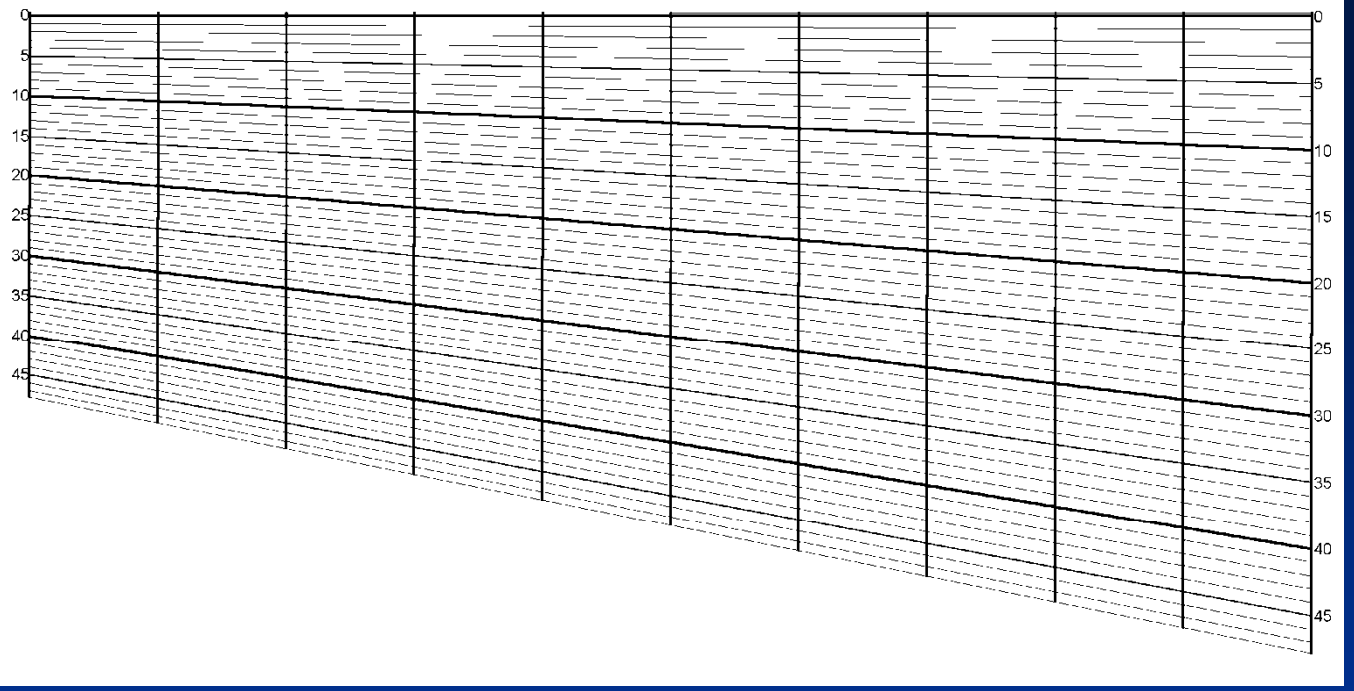
Anteversion (degrees)
inclination 30
inclination 35
inclination 40
inclination 45
inclination 50
inclination 55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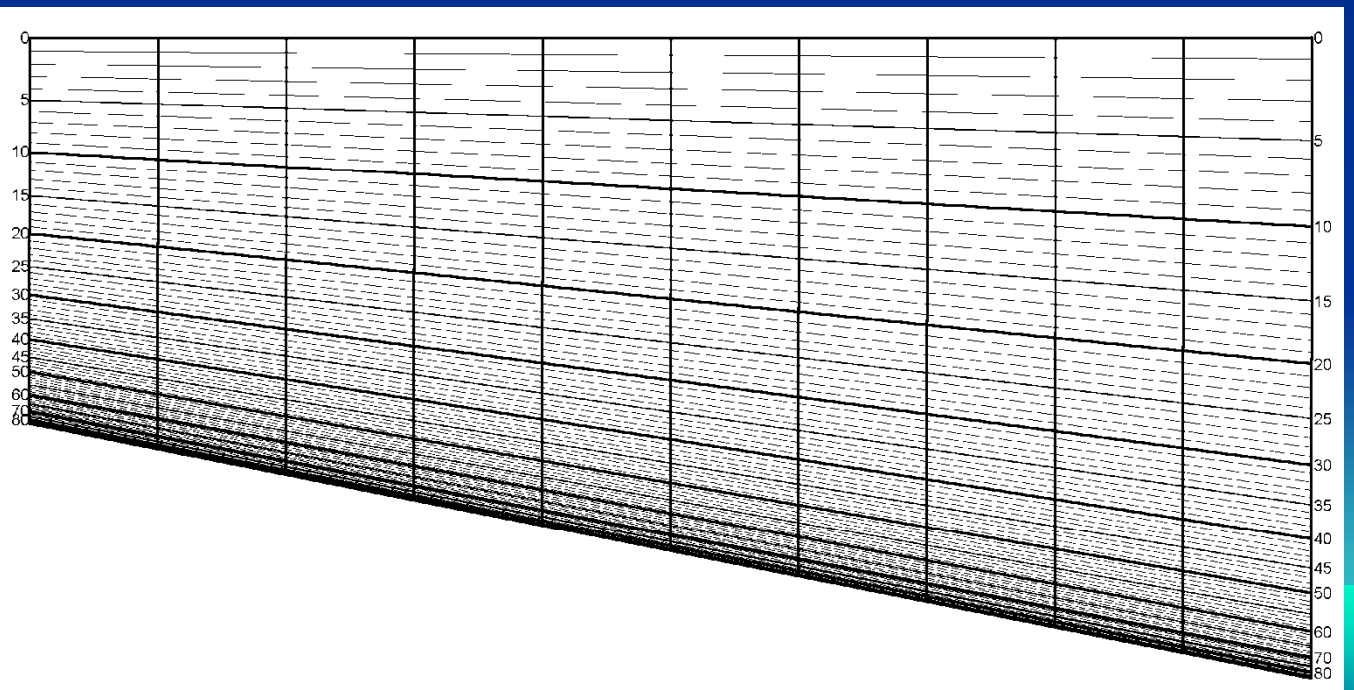
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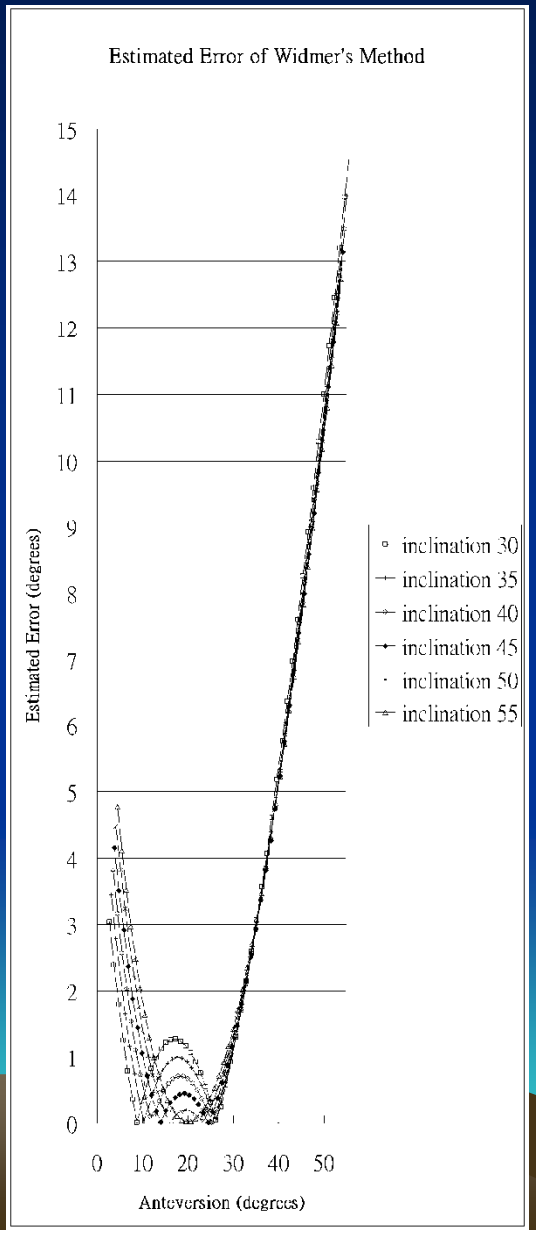
Proposed Methods

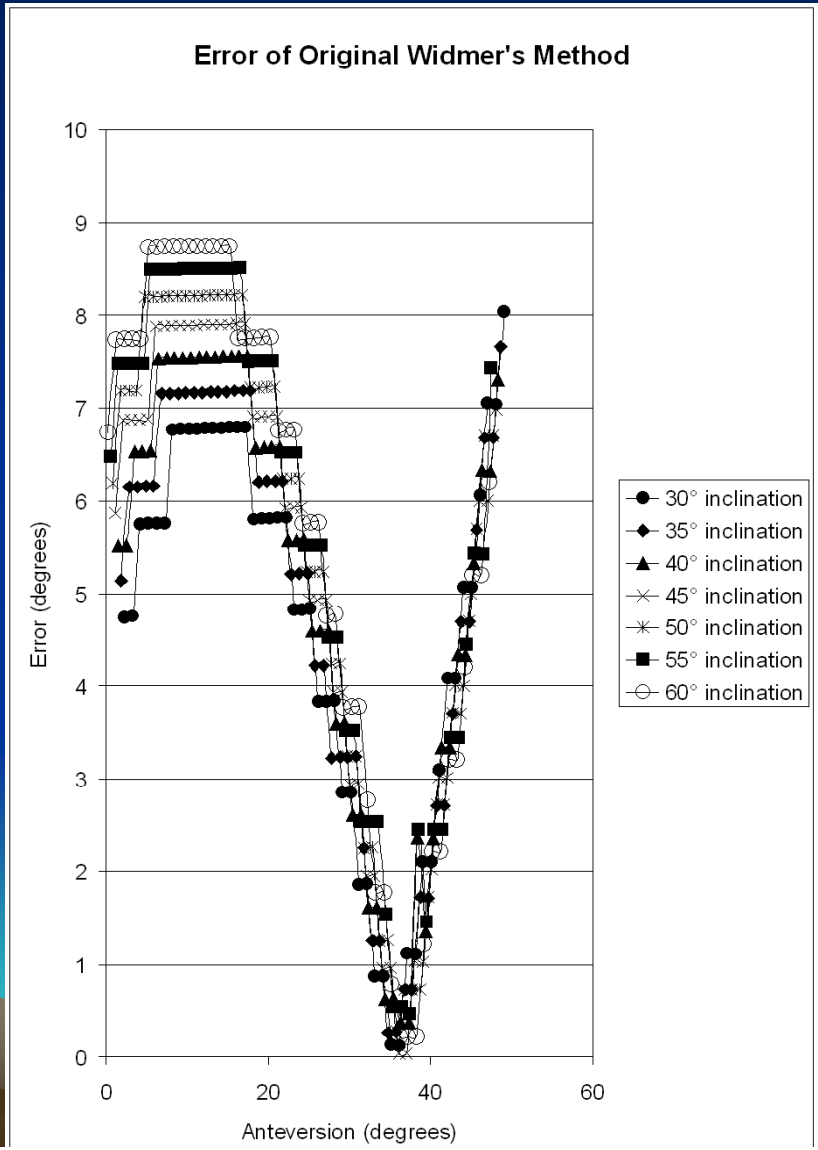
- We simulate 336 total hip arthroplasty radiographs with 48 different anteversions ranging from 5°–52° and seven different inclinations (30°, 35°, 40°, 45°, 50°, 55°, and 60°) using our *Simulator*.
- Measure the anteversion of the 336 radiographs with our improved method and with Widmer's method.
- Compared with pair *t*-test.

Materials and Methods

- We randomly select ten hip arthroplasty radiographs and measure the radiographic anteversion with our method and Widmer's method twice each by one of the authors.

Results


Estimated Error of Widmer's Method
Estimated Error (degrees)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
10
20
30
40
50
Anteversion (degrees)
inclination 30
inclination 35
inclination 40
inclination 45
inclination 50
inclination 55


Error of Original Widmer's Method
Error (degrees)
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
Anteversion (degrees)
30° inclination
35° inclination
40° inclination
45° inclination
50° inclination
55° inclination
60° inclination

Results

- For simulated radiographs
- Max error:
  - Ours: 3°
  - Widmer's: 8.7°
- Mean error:
  - Ours: 0.8°
  - Widmer's: 5.2°
- There is statistical difference between the two methods. ($p<0.0001$)

Results

- For real radiographs
- Inter-measurement difference
  - Absolute difference
    - Ours: 0° to 1°
    - Widmer's: 0° to 2°


Accuracy of Measurement of Acetabulum Anteversion with Radiographs of Total Hip Replacements
Chen-Kun Liaw[1,3] Rong-Sen Yang[2] Sheng-Mou Hou[2] Chiou-Shann Fuh[3] Tai-Yin Wu[4]
En Chu Kong Hospital, Taipei Hsian, Taiwan[1]
National Taiwan University Hospital, Taipei, Taiwan[2]
National Taiwan University, Computer Science and Information Engineering[3]
Taipei City Hospital[4]
Abstract
Introduction
Lewinnek method
Liaw method
Widmer method
Methods
•45 simulated total hip replacement radiographs
•15 different anteversions and randomized inclinations and wear
•Measured with the Lewinnek method, the Liaw method, the modified Widmer method, and the Fabeck method
•Blind method
•Pair t test, p<0.05 as significant.
Results
With simulated radiographs, median errors are 1° with the Liaw and Widmer and Fabeck methods, and 1.23° with the Lewinnek method. Maximum errors are between 2.61° (Lewinnek) and 3° (Liaw, Widmer, and Fabeck). Mean errors are 1.28° with the Lewinnek method, 0.96° with the Liaw method, 1.16° with the modified Widmer method, and 0.89° with the Fabeck method.
There are no statical differences between these methods.
Conclusions
•All four methods have acceptable results on measuring anteversion.
•Liaw and modified Widmer methods are easier because the examiner do not have to draw line on radiographs.
Results
Method :
U.C.L.A. Activity Score
Step Test
Conclusion
25 8:36PM

Liaw's Version – A New Standardized Version of Acetabular Prosthesis

Computational and Mathematical Methods in Medicine
Vol. 00, No. 0, 2008, 1–15

Taylor & Francis
Taylor & Francis Group

A simple mathematical standardized measurement of acetabulum anteversion after total hip arthroplasty

Chen-Kun Liaw[a,d1,5], Rong-Sen Yang[b2,5], Sheng-Mou Hou[b3], Tai-Yin Wu[c4] and Chiou-Shann Fuh[d*]

Position Problems

- Position will interfere the anteversion we measure.
- Position problems include
  - X-ray tube position
  - Film position
  - Patient position

X Ray Tube Position

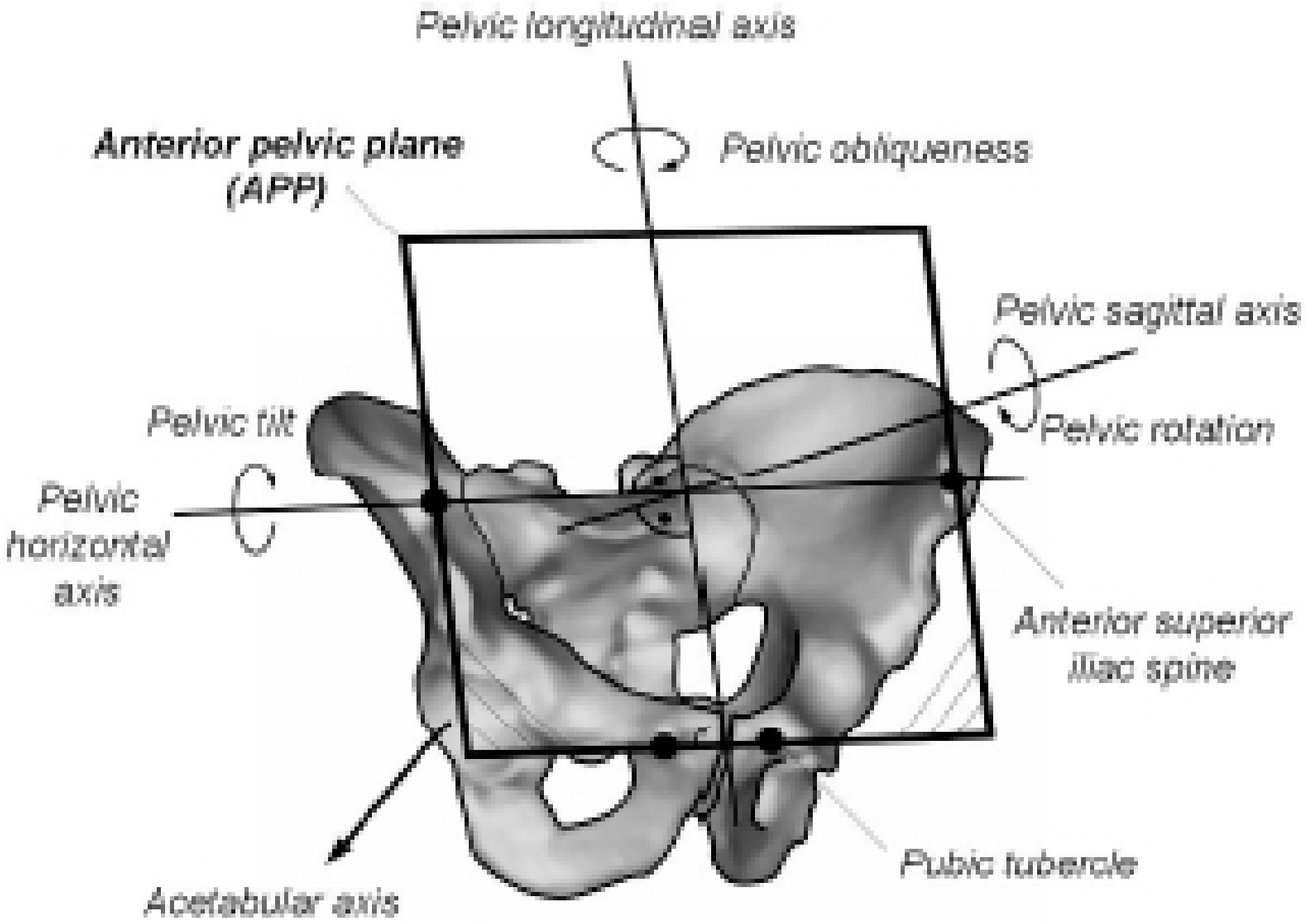
- 100 cm above the patient
- Pelvis AP view
  - Centered at symphysis pubis
- Hip AP view
  - Centered at femoral head (acetabulum)

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

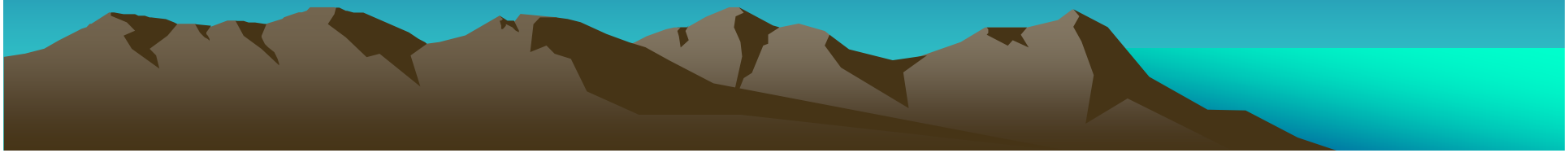
Patient Position

- 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


Pelvic longitudinal axis
Anterior pelvic plane (APP)
Pelvic obliqueness
Pelvic sagittal axis
Pelvic rotation
Pelvic tilt
Pelvic horizontal axis
Anterior superior iliac spine
Pubic tubercle
Acetabular axis

Position Problem

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

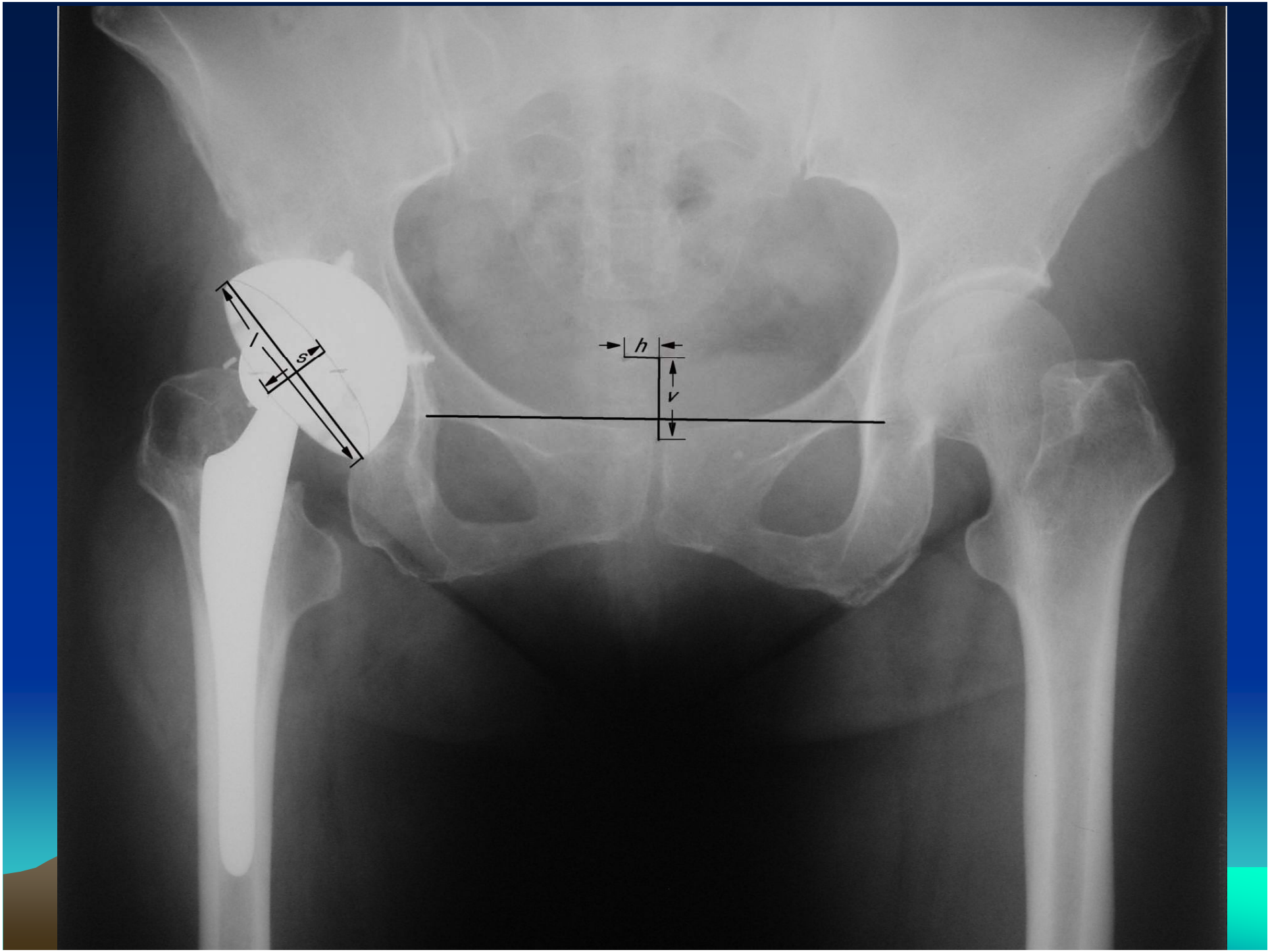


Patient Position Problem

- 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.

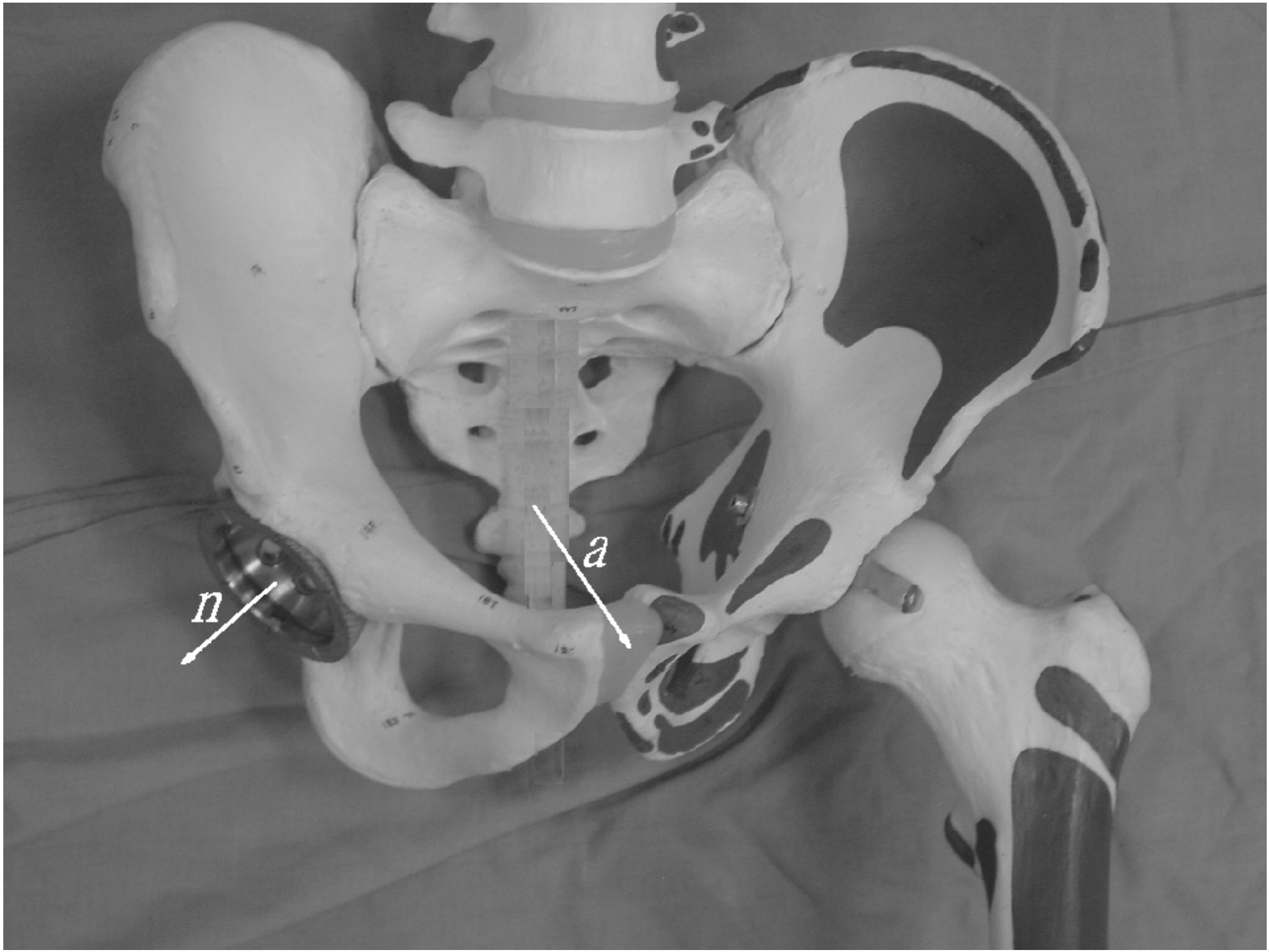
Our Solution

- 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.


l
s
h
v

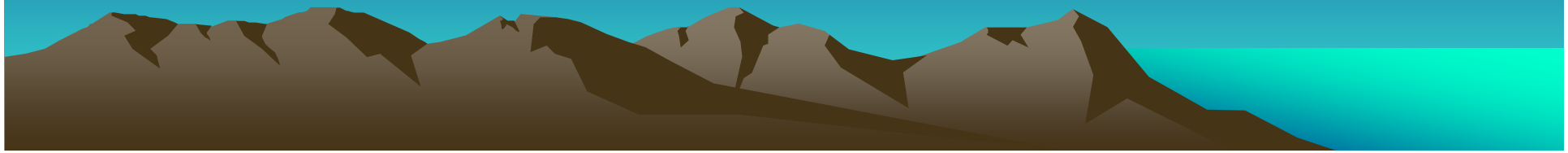
Our Definition of Anteversion

- 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 (Liaw's version): the angle between the plane of acetabulum and pelvis radiographic axis

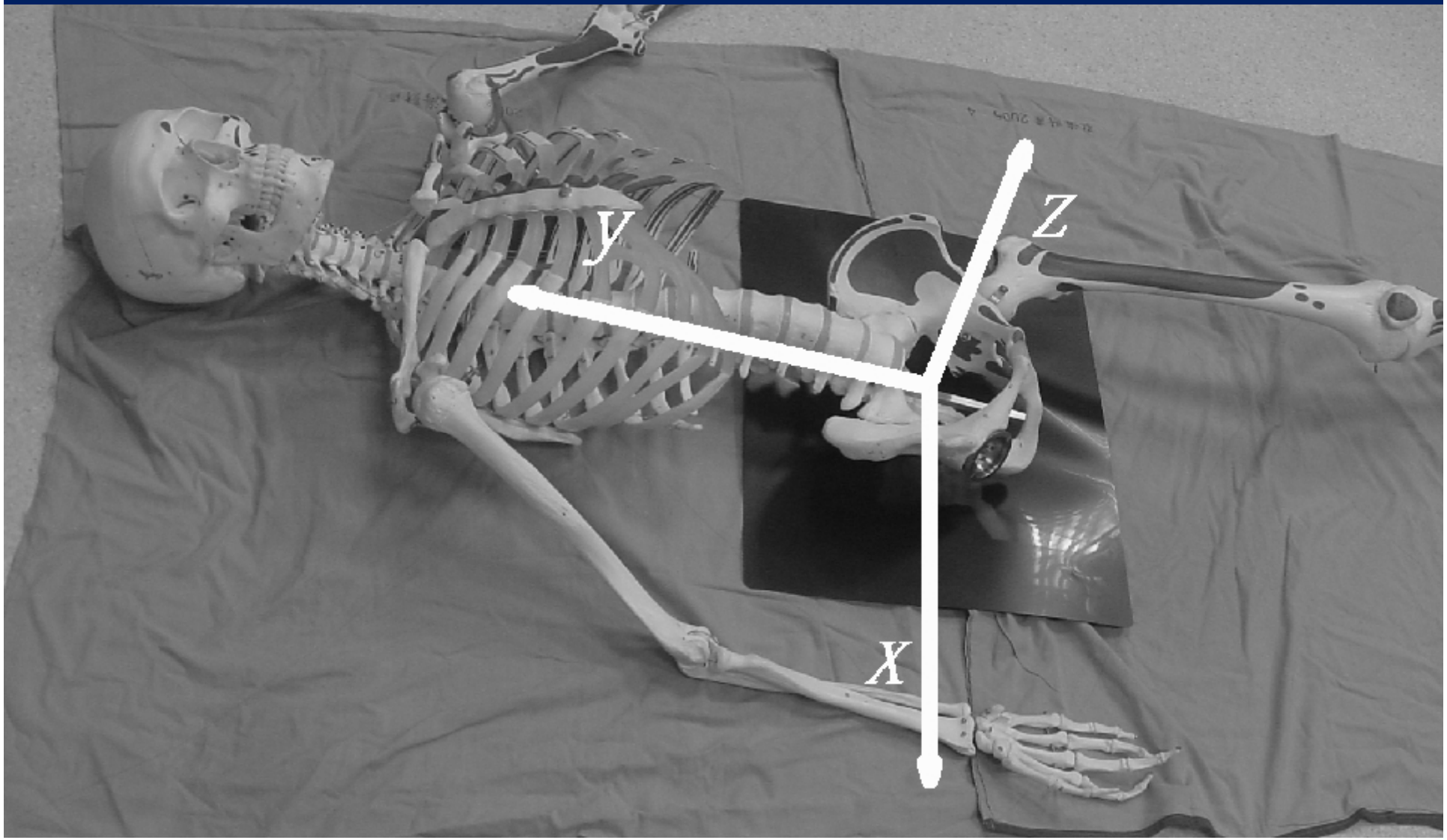

a
n

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.

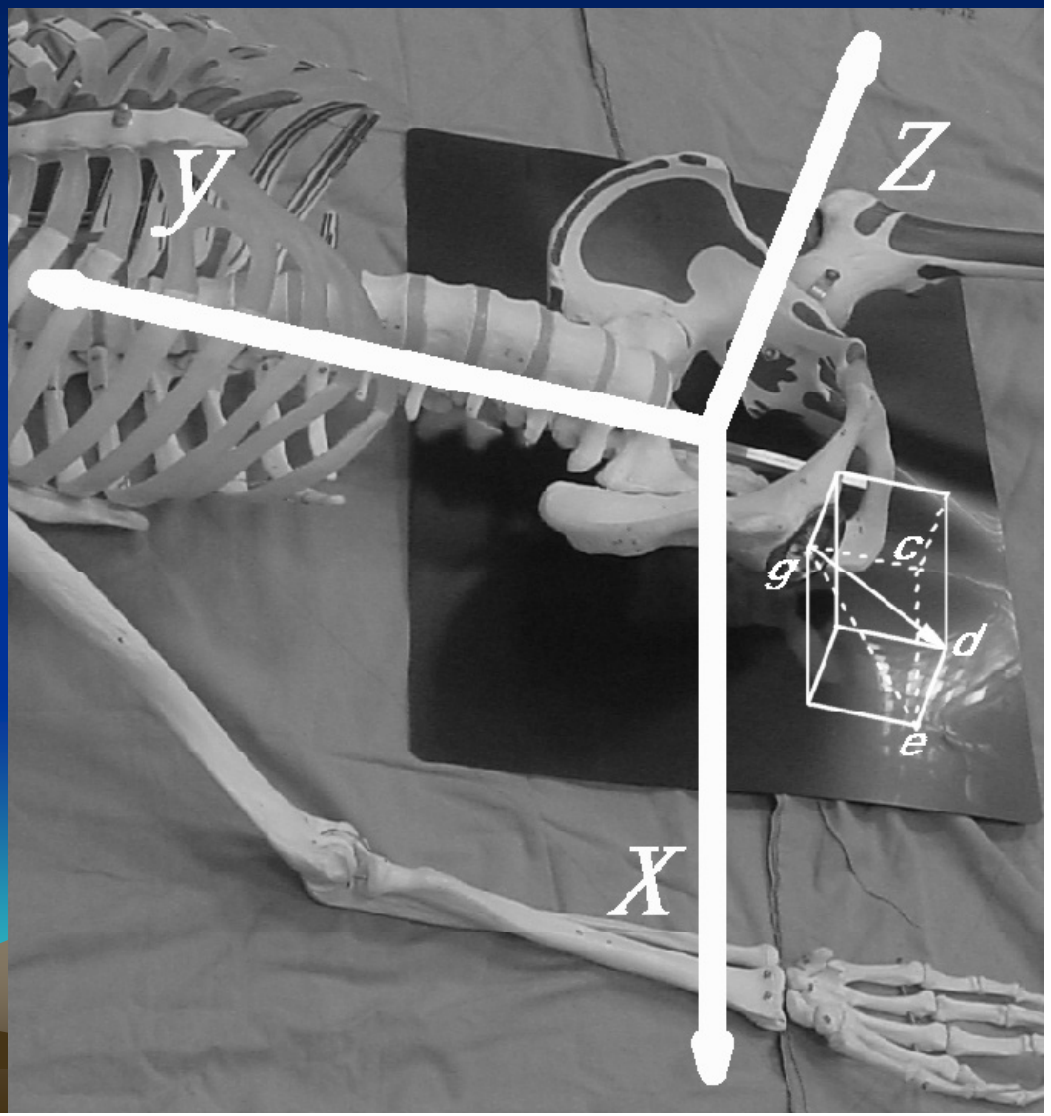


Cartesian Coordinate System



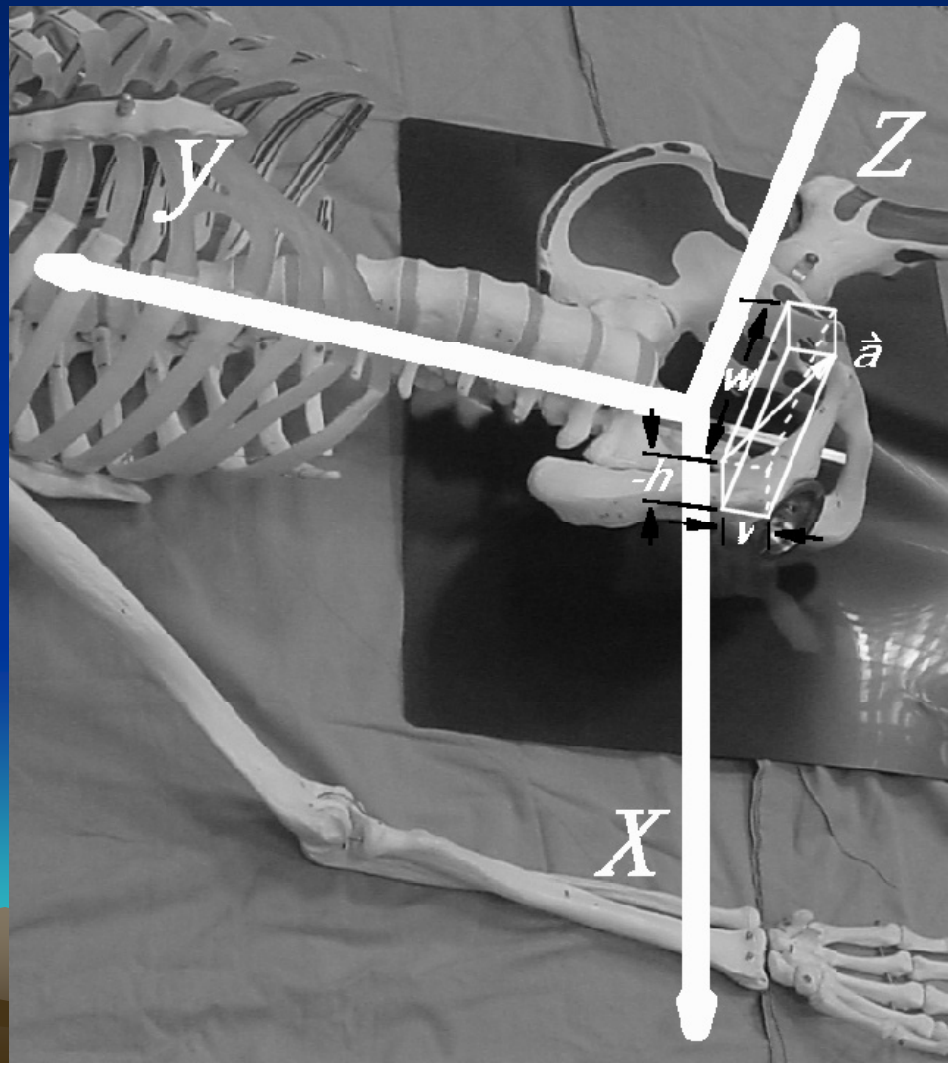
Normal Vector of Acetabulum

- Anteversionθ = $\angle dge$
- Inclinationφ = $\angle cge$
- 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.

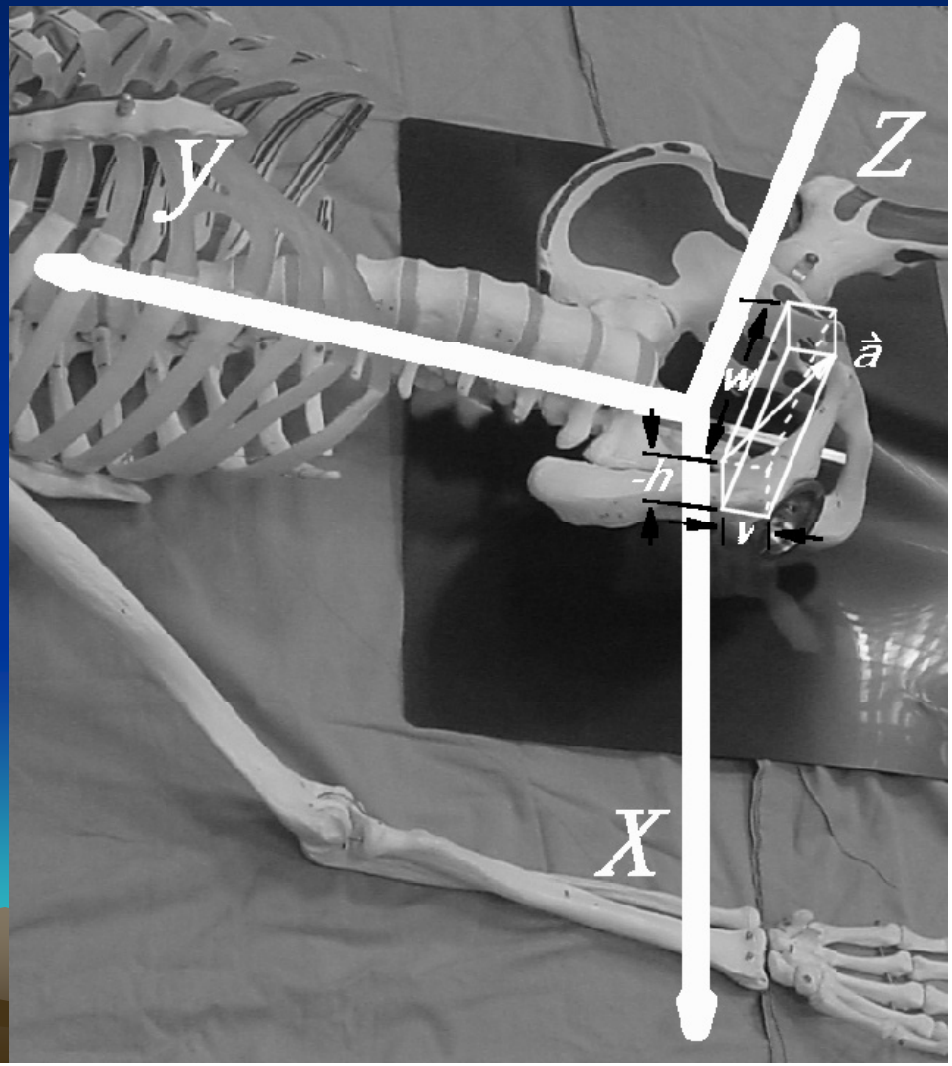


Vector of Pelvis Radiographic Axis

- *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*=

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

ssd: distance from sacrococcygeal junction to upper pole of symphysis publs



Angle between the Two Vectors

- ω = angle between the two vectors
- $\cos\omega$= (vector *a* dot vector *n*)/(length of vector *a** length of vector *n*)
- $\omega = \cos^{-1}$((vector *a* dot vector *n*)/(length of vector *a** length of vector *n*))

Radiographic Standardized Anteversion

- radiographic standardized anteversion=

  90 degrees – ω

  $=90 \text{ degrees} -$

  $\cos^{-1}((-h * \sin\varphi * \cos\theta + v * \cos\varphi * \cos\theta + \sin\theta * (ssd^{2} - h^{2} - v^{2})^{0.5})/ssd)$

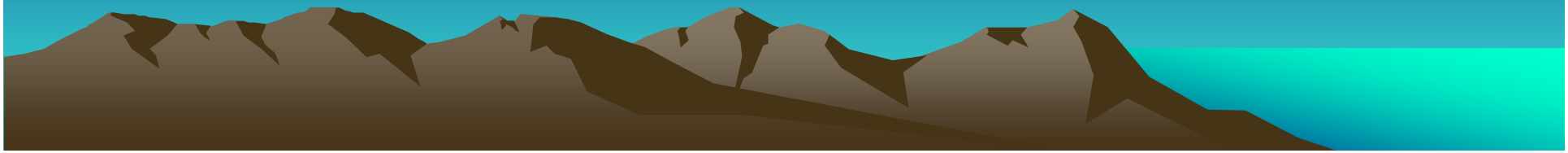
  $= \sin^{-1}((-h * \sin\varphi * \cos\theta + v * \cos\varphi * \cos\theta + \sin\theta * (ssd^{2} - h^{2} - v^{2})^{0.5})/ssd)$

Material and Methods

- We measure *ssd* of 109 normal adults from lumbar-saccral lateral view radiographs.
- We collect ten patients who received total hip arthroplasty in En Chu Kong 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.



Materials and Methods

- We calculate the standard deviation for all measurement of each patient and RSD (Repeatability Standard Deviation) from ASTM E691 for comparison.
- The RSD can be seen as standard deviation.
- The lower RSD, the better.

Materials and Methods

$$S = \sqrt{\frac{\sum_{j=1}^{c}\sum_{i=1}^{n}(X_{ij}-\overline{X}_j)^2}{\sum_{j=1}^{c}(n_j-1)}}$$

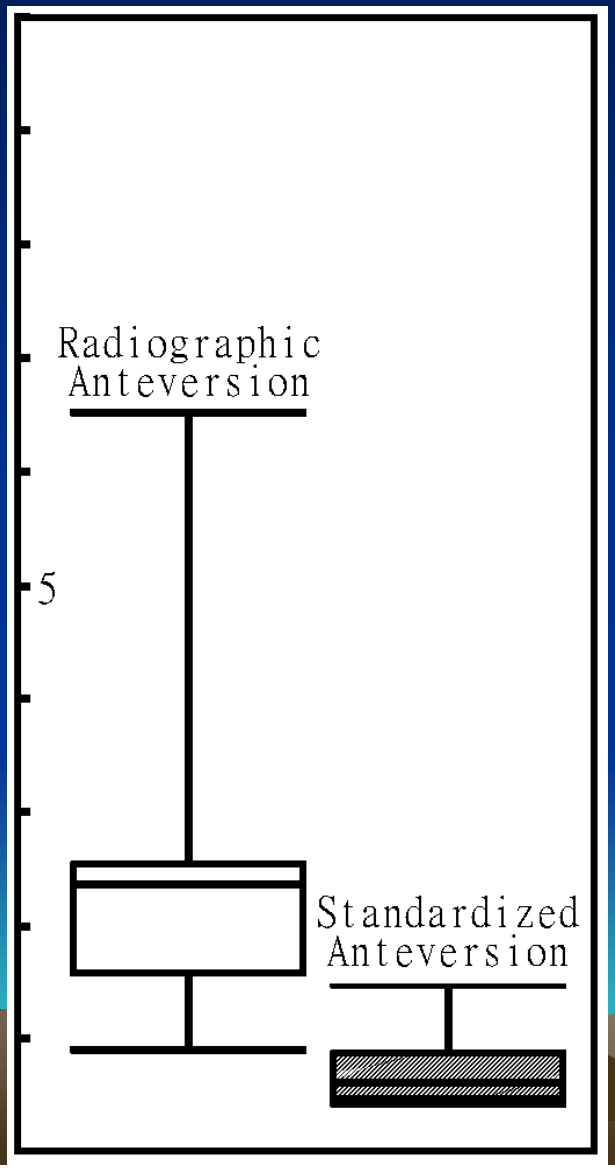
- X_{ij} means the result of the *j*th patient, the *i*th X-rays' measurement; $\overline{X}_j$ means the mean result of the *j*th patient; and n_j means the total number of measurement of the *j*th patient.

Results

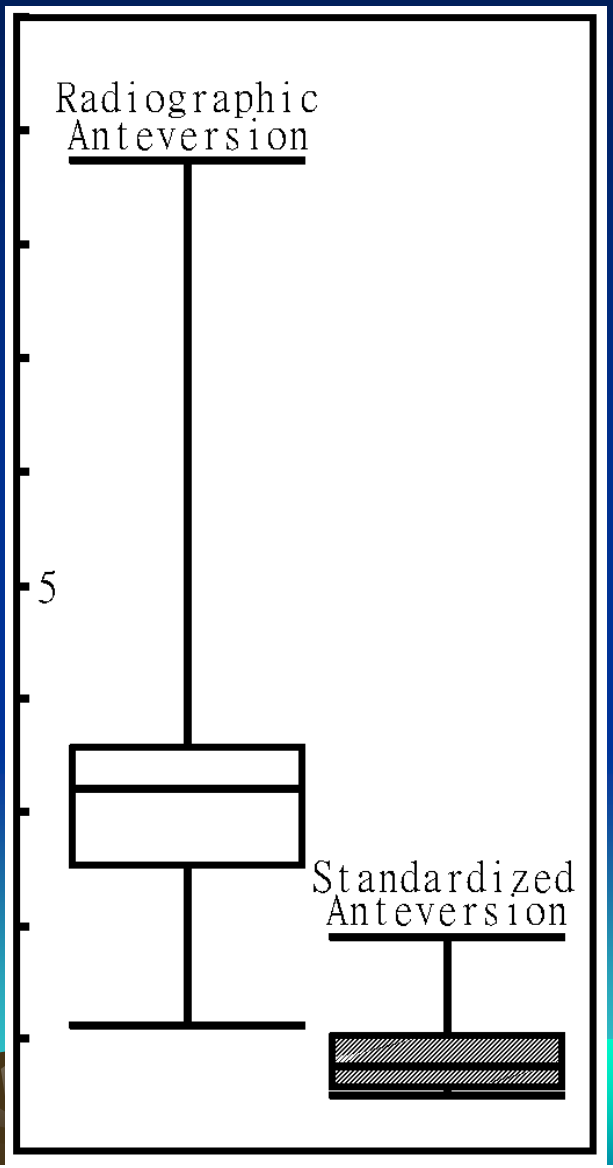
- *ssd*
  - Male: 137 to 190mm, 159 ± 12mm
  - Female: 138 to 183mm, 160 ± 12mm
  - Total: 137 to 190mm, 159 ±12mm
  - No sex difference. (p=0.91)
  - Considering magnification factor, we apply the result "*ssd*=159×0.9=143" to standardize equation.

Results

Absolute difference



Standard deviation



Results

Patient	Number of radiogram of each patient	Radiographic Anteversion						Standardized Anteversion					
		Min*	Median	Max*	Mean	STD*	MAD*	Min*	Median	Max*	Mean	STD*	MAD*
1	3	6.2	11.3	11.5	9.67	3.02	2.32	15.8	17.0	17.1	16.6	0.73	0.56
2	6	7.0	12.2	18.2	12.3	3.62	2.40	17.0	18.0	18.4	17.8	0.55	0.43
3	4	0	17.1	17.9	13.0	8.73	6.52	13.7	16.6	17.9	16.2	1.90	1.46
4	10	10.3	13.5	21.0	13.9	3.17	2.30	27.6	30.1	31.5	29.8	1.39	1.14
5	11	12.9	15.3	23.1	16.4	3.43	2.59	21.1	22.4	24.1	22.6	0.99	0.81
6	5	24.9	26.4	32.9	27.6	3.25	2.42	27.6	28.5	28.9	28.3	0.54	0.44
7	8	11.6	13.2	14.8	13.1	1.11	0.89	23.6	24.5	25.6	24.6	0.77	0.65
8	5	10.8	11.4	15.1	12.3	1.73	1.33	17.0	17.4	18.3	17.6	0.56	0.47
9	8	8.3	12.4	20.9	13.4	3.99	3.09	7.5	8.7	10.2	8.9	1.04	0.89
10	8	9.1	12.7	14.1	12.4	1.48	0.90	14.6	15.2	16.1	15.3	0.50	0.42
	Total: 68					**RSD: 3.50	Average: 2.30					**RSD: 0.99	Average: 0.75

*Min: minimal
Max: maximal
STD: standard deviation
MAD: mean of absolute deviation
** RSD: Repeatability Standard Deviation

Discussion

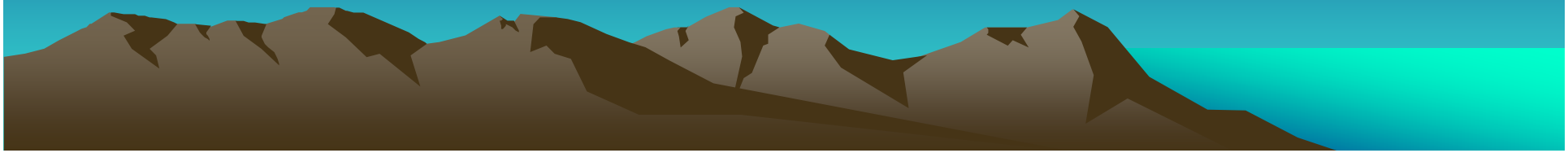
- CT standardization method:
  - average of absolute deviation: 2.3°
  - standard deviation: 2.9°
- Liaw version:
  - average of absolute deviation: 0.75°
  - repeatability standard deviation: 0.99°

Summary

- We provide a digital *Simulator* as gold standard for acetabular component orientation study.
- We invent a new protractor.
- We improve the precision of Widmer's protractor.
- We invent a new two-dimensional standardized anteversion, Liaw version, to solve the position problem.

Conclusion

- Some of our studies have been published in medical and mathematical journals (see Appendix E), we hope the future studies can use our inventions.



謝謝收看 !!

Publications

- [A] Journal Papers
- Liaw CK, Yang RS, Hou SM, et al. A Simple Mathematical Standardized Measurement of Acetabulum Anteversion after Total Hip Arthroplasty. *Computational and Mathematical Methods in Medicine.* (in press) (C*J*A 3*.5*5=7.5)
- Liaw CK, Yang RS, Hou SM, et al. Measurement of the the Acetabular Cup Anteversion on the Simulated Radiographs. *J Arthroplasty.* (in press). (SCI 9/43 impact 1.806) (C*J*A 3*5*5=75)
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- J. K. Liaw, S. H. Liaw, R. S. Yang, S. M. Hou Reverse drilling technique in inserting distal locking screws of interlocking nail. J. Orthop Surg. R.O.C. 18:115-119, 2001.
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- 2. 臨床骨折學. 楊榮森 蔡文基 簡君儒 廖振焜 蔡凱宙 曾效祖 1998合記圖書出版社

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- [C] Conference papers
- A Simplified Guide Ruler for Rotational Osteotomy. 廖振焜 許祐堡 楊南屏 游敬孝 傅楸善 楊榮森 王崇禮 侯勝茂 2007 骨科醫學會 聯合學術研討會.
- Measurement of the the Acetabular Cup Anteversion on the Simulated Radiographs. Chen-Kun Liaw Rong-Sen Yang Sheng-Mou Hou Chiou-Shann Fuh Tai-Yin Wu Fifth SICOT/SIROT Annual International Conference 29 August 2007 Marrakech, Motocco.
- Percutaneous Repair of Neglected Achilles Tendons Rupture以經皮穿刺修補忽視的跟腱斷裂 廖振焜 戴瀚成 吳長晉 林大弘 楊榮森 王崇禮 侯勝茂 中華民國骨科醫學會96年度春季聯合學術研討會
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- Simulated Radiograph of Total Hip Arthroplasty for Verifying Measuring Instrument. Chen-Kun Liaw Rong-Sen Yang Sheng-Mou Hou Chiou-Shann Fuh Tai-Yin Wu Fourth SICOT/SIROT Annual International Conference 23-26 August 2006 Buenos Aires, Argentina.
- A New Tool for Measuring Cup Orientation in Total Hip Arthroplasty. Chen-Kun Liaw Rong-Sen Yang Sheng-Mou Hou Chiou-Shann Fuh Tai-Yin Wu Fourth SICOT/SIROT Annual International Conference 23-26 August 2006 Buenos Aires, Argentina.
- Accuracy of Measurement of Acetabulum Anteversion with Radiographs of Total Hip Replacements. Chen-Kun Liaw Rong-Sen Yang Sheng-Mou Hou Chiou-Shann Fuh Tai-Yin Wu Fourth SICOT/SIROT Annual International Conference 23-26 August 2006 Buenos Aires, Argentina.
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- OCM Approach for Hip Arthroplasty-En Chu Kong Experience廖振焜 侯勝茂 中華民國骨科醫學會95年度春季聯合學術研討會
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- Accuracy of Measurement of Acetabulum Anteversion with Radiographs of Total Hip Replacements 廖振焜 林大弘 吳長晉 戴瀚成 傅楸善 楊榮森 侯勝茂 2005 骨科醫學會 聯合學術研討會.
- Automatic Digital PE Wear Measurement. Chen-Kun Liaw, Tai-Yin Wu, Sheng-Mou Hou, Rong-Sen Yang, Chiou-Shann Fuh, Shong-Hon Liao, Chang-Chin Wu, Han-Cheng Tai, Dah-Hsiang Liu. 2005 AAOS annual meeting Scientific Exhibition.
- A New Tool for Measuring Cup Orientation in MIS Total Hip Arthroplasty Chen-Kun Liaw, Sheng-Mou Hou. 4th annual scientific symposium Orthopaedic Update: MIS Surgery Series, 2005, Gold Coast.

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- Templater: Solution for Preoperative Planning on Picture Archiving and Communication Systems (PACS) 廖振焜 吳長晉 劉大祥 戴瀚成 傅楸善 楊榮森 侯勝茂 2004 骨科醫學會 聯合學術研討會.
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- Small Incision Hip Arthroplasty廖振焜 侯勝茂2002 骨科醫學會 聯合學術研討會.
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