An Improved Method of Measuring Anteversion

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Radiographic Anteversion, Planar Anteversion

Introduction

- Three groups of measuring anteversion methods
  - Computer tomography methods
  - Trigonometric methods
  - Protractor methods

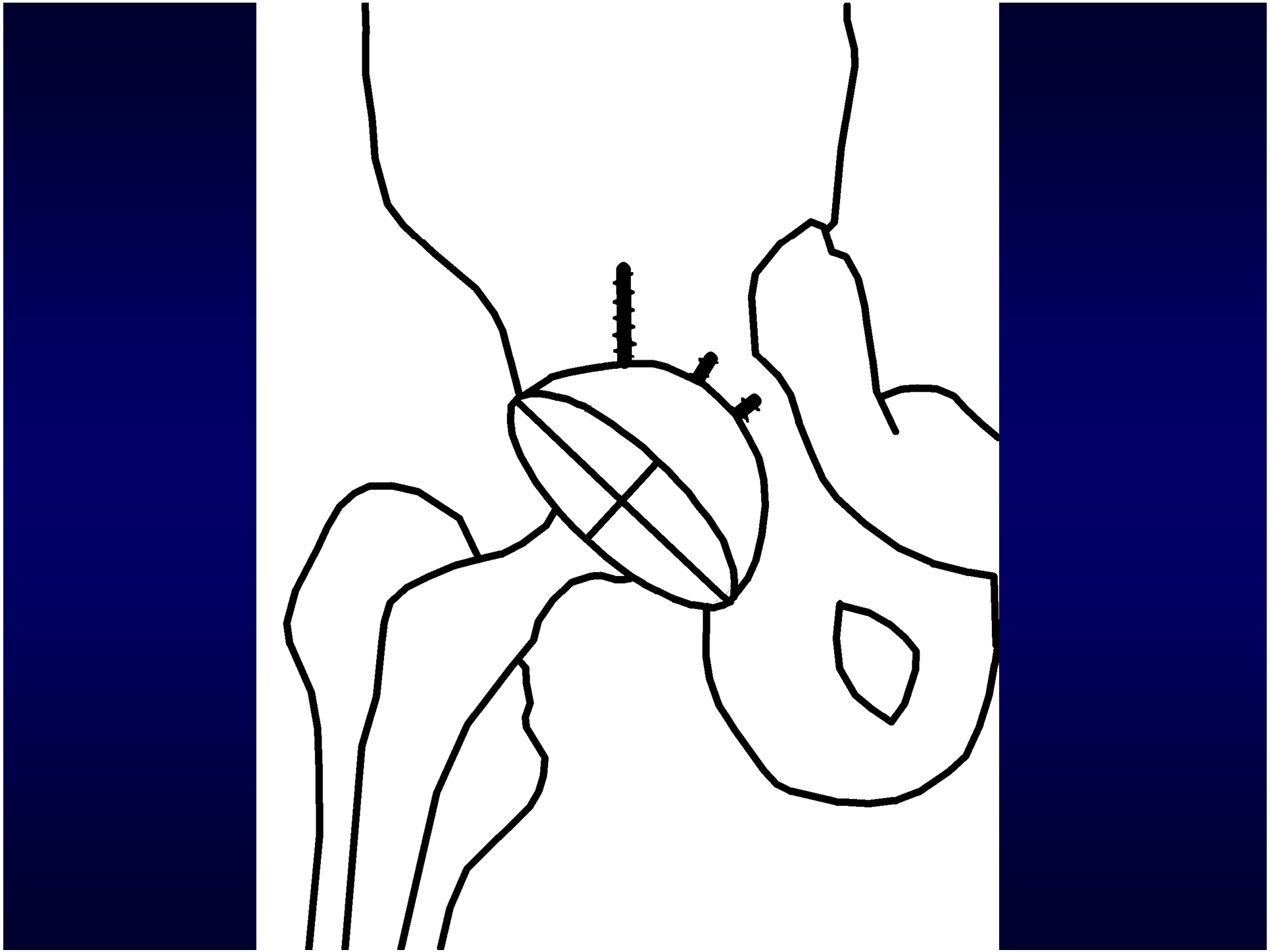
Computer Tomography Methods

- CT images in 10 patients
- Anteversion 0-52 degrees
- Inclination 30-65 degrees
- Error is 2.9 degrees

- Olivecrona H, Weidenhielm L, Olivecrona L, Beckman MO, et al. A new CT method for measuring cup orientation after total hip arthroplasty: A study of 10 patients. *Acta Orthop Scand*. 75:252–260, 2004.

Trigonometric Method

- Lewinnek method
- Measure short axis and long axis of the ellipse
- $\beta = \sin^{-1}$ (short axis of the ellipse / long axis of the ellipse)
- Error is 1.2 ± 0.57 degrees

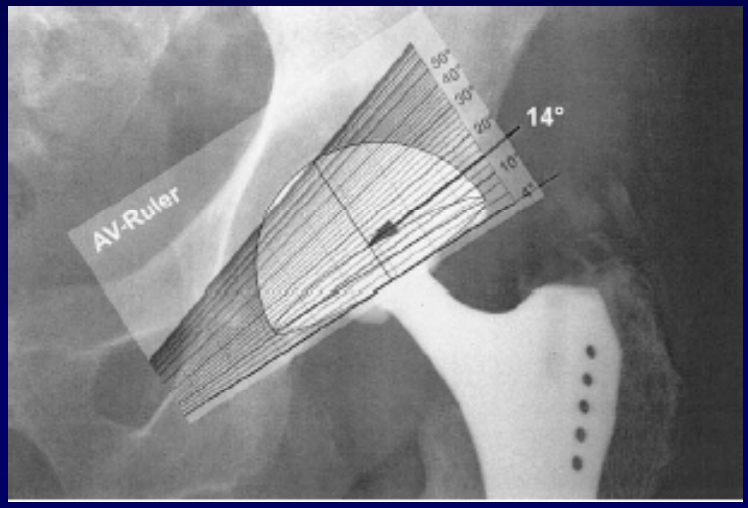


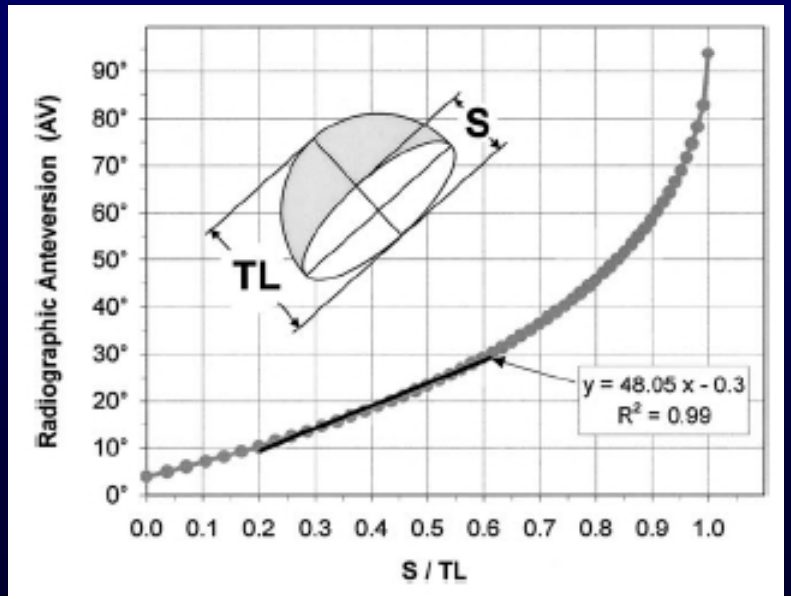
Protractor Method

- Convenient
- Liaw's protractor
- Fabeck's protractor
  - Hard to align the line during measurement
- Widmer's protractor
  - Easy to use
  - Imprecise

Widmer's Protractor

- Error
  - Systemic error
  - Operational error
  - Systemic error is correctable
- Widmer's formula
- Anteversion= 48.5*(*S*/*TL*)-0.3





Causes of Systemic Error

- Approximate curve with linear regression
  - Solution: find the formula mathematically
- Ignore the influence of different inclinations in oblique projection
  - Solution: take X-ray centered in the hip

Deduction of the Formula

- Lewinnek et al.[6] described an equation to measure radiographic (planar) anteversion β.
  - $\beta = \sin^{-1}(s / l)$ (1)

When we measure the anatomic (true) anteversionα. The length of short axis in this equation is changed.

$\alpha = \sin^{-1}(s_d / l)$ (2)

Deduction of the Formula

- By Murray's report

$\alpha = \tan^{-1}(\tan\beta\csc\gamma)$ (3)

$\beta = \tan^{-1}(\tan\alpha\sin\gamma)$ (4)

Deduction of the Formula

- $TL=(l+S)/2$
- $TL=S/(S/\text{TL-ratio})$
- $l=2\,TL-S=2S/(S/\text{TL-ratio})-S$
- $S/l=S/(2S/(S/\text{TL-ratio})-S)=(S/\text{TL-ratio})/(2-(S/\text{TL-ratio}))$
- $\beta=\sin^{-1}(S/l)=\sin^{-1}((S/\text{TL-ratio})/(2-(S/\text{TL-ratio})))$ (5)

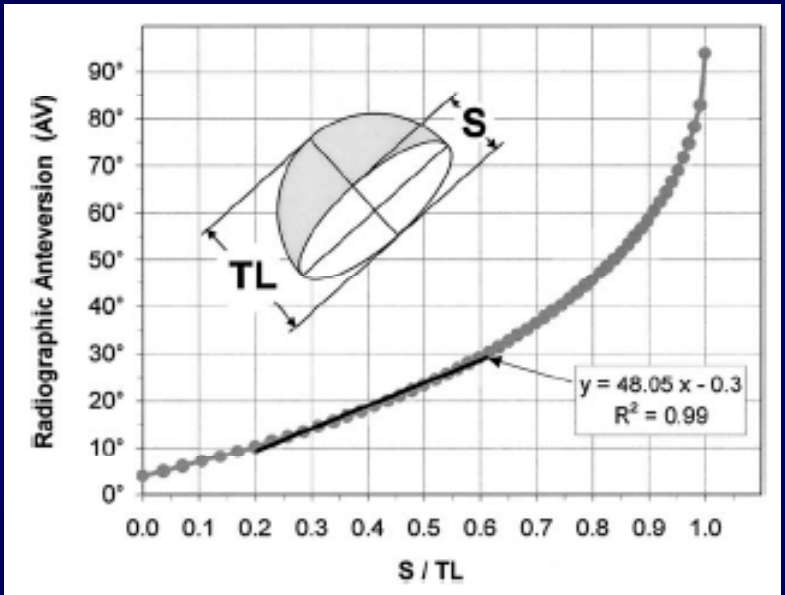
Deduction of the Formula

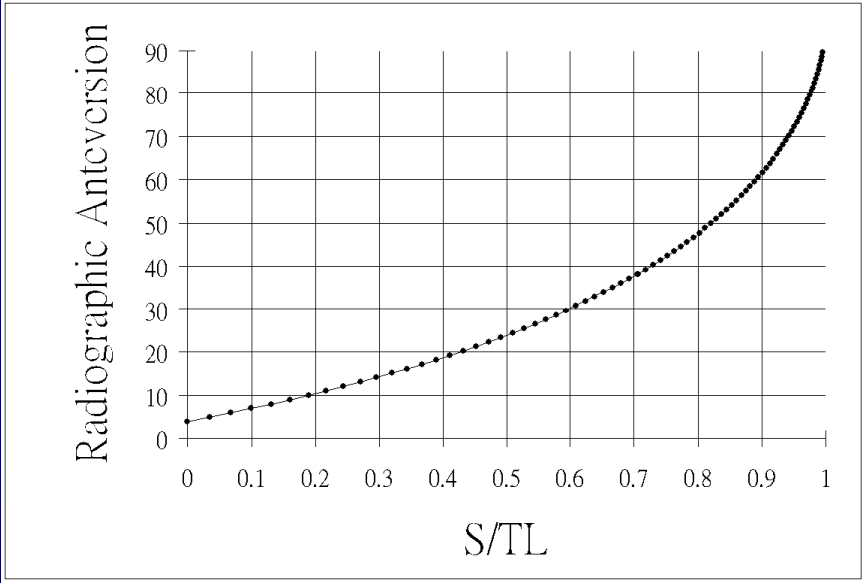
- After we calculate$\beta$by Equation 5. We can calculateα by Equation 3.
- $\alpha = \tan^{-1}(\tan(\sin^{-1}((S/TL\text{-}ratio)/(2-(S/TL\text{-}ratio))))\csc\gamma)$ (6)
- The anatomic anteversion must be corrected due to oblique projection.
- $\alpha = \tan^{-1}(\tan(\sin^{-1}((S/TL\text{-}ratio)/(2-(S/TL\text{-}ratio))))\csc\gamma) + 5.46^{\circ}$ (7)

Deduction of the Formula

- Then we can calculate radiographic anteversion from anatomic anteversion from Equation 4.
- $\beta = \tan^{-1}(\tan(\tan^{-1}(\tan(\sin^{-1}((S/TL\text{-}ratio)/(2-(S/TL\text{-}ratio))))\csc\gamma) + 5.46^{\circ})\sin\gamma)$ (8)

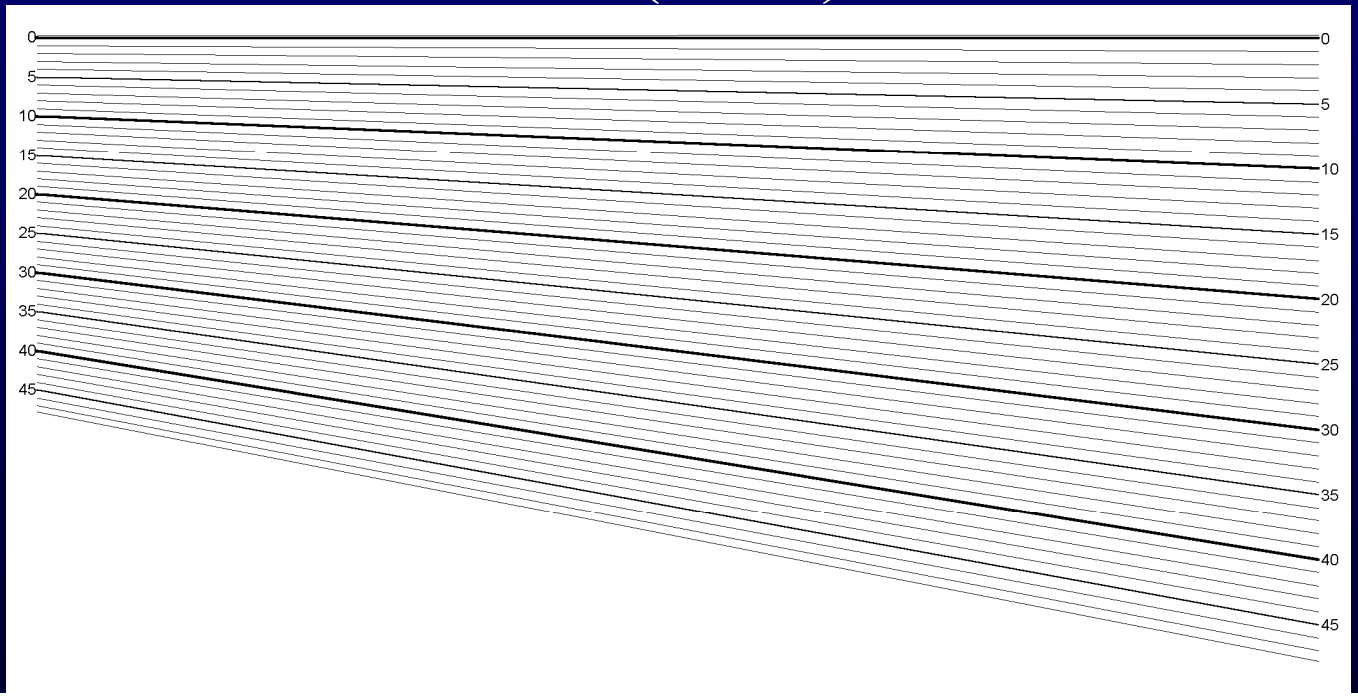
Result of New Formula





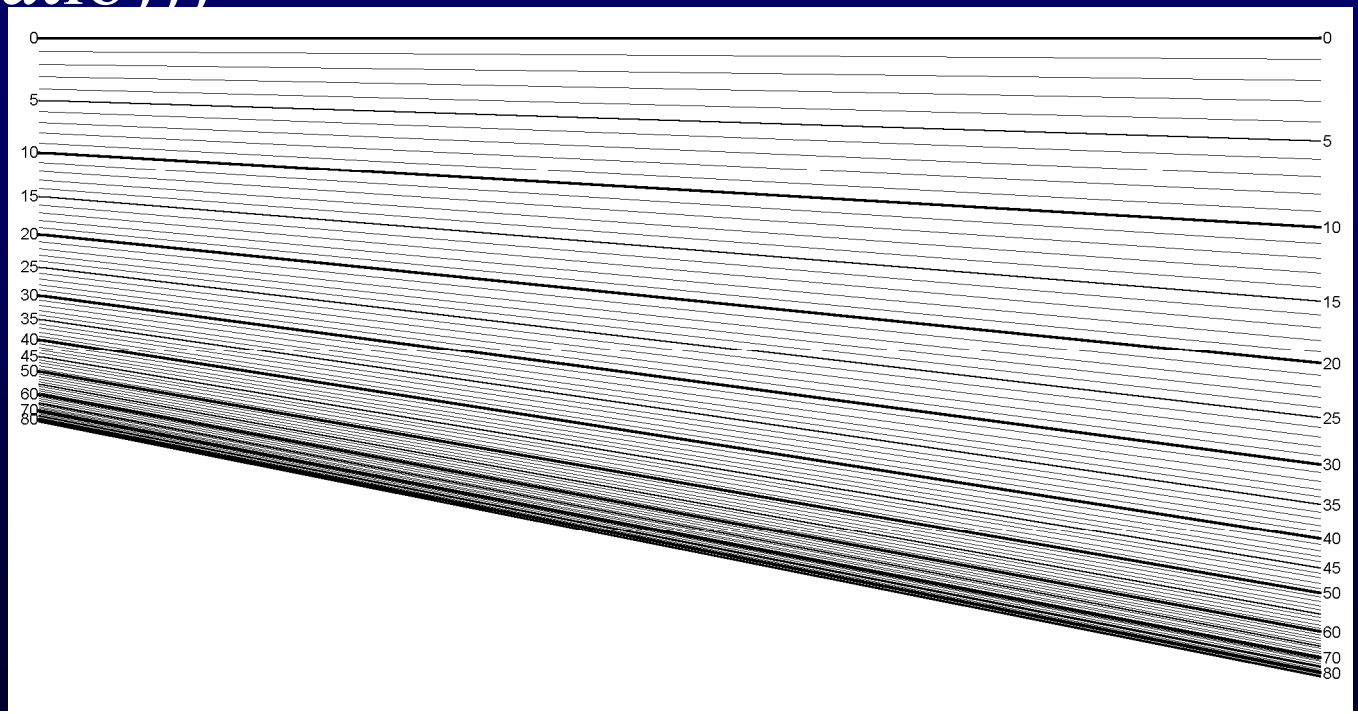
Methods

- Prepared Widmer's protractor by his linear regression formula
- Anteversion= 48.5*(*S*/*TL*)-0.3



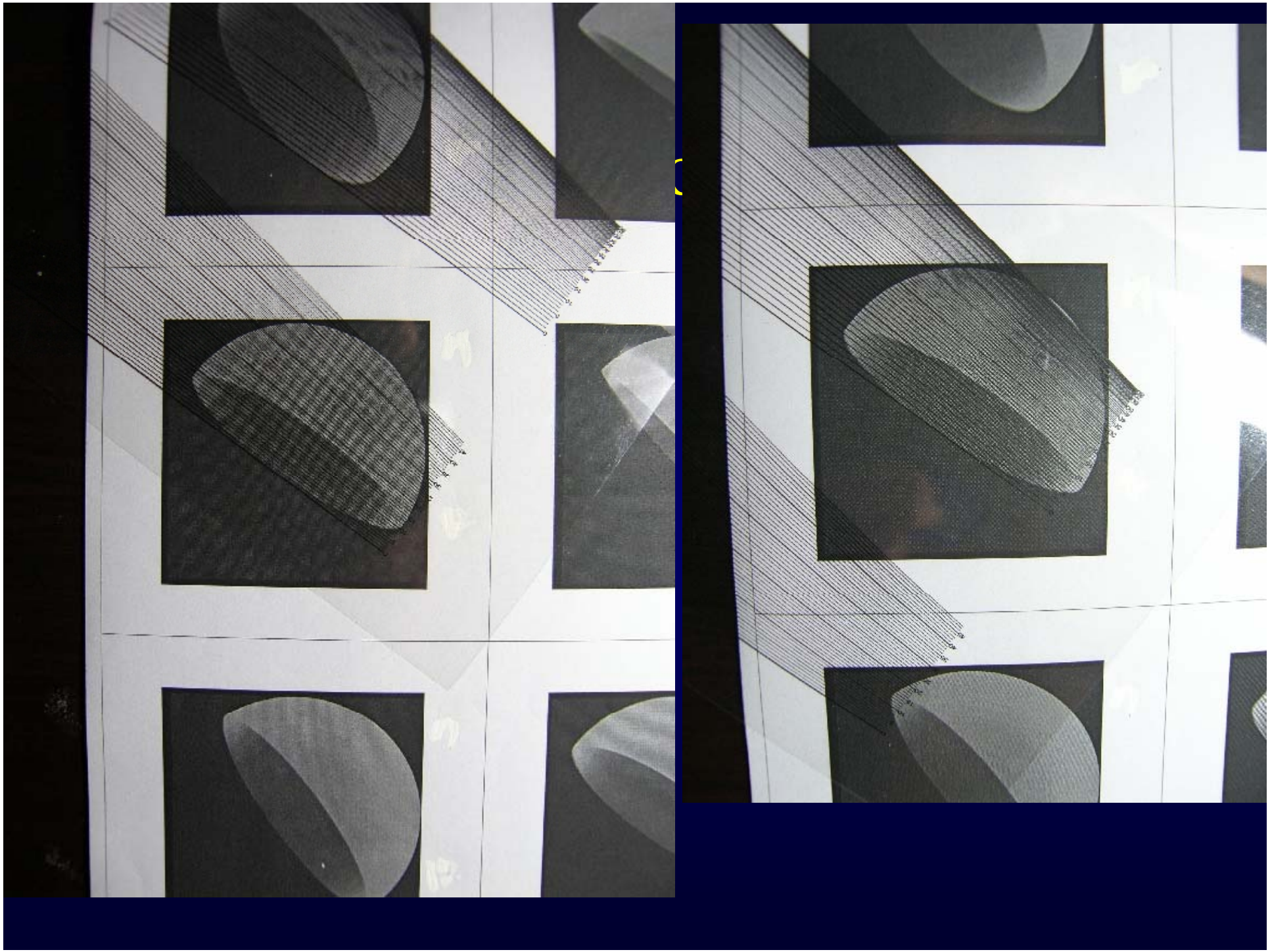
Methods

- Prepared Our protractor by our formula
- Anteversion= $\sin^{-1}((S/TL\text{-ratio})/(2-(S/TL\text{-ratio})))$



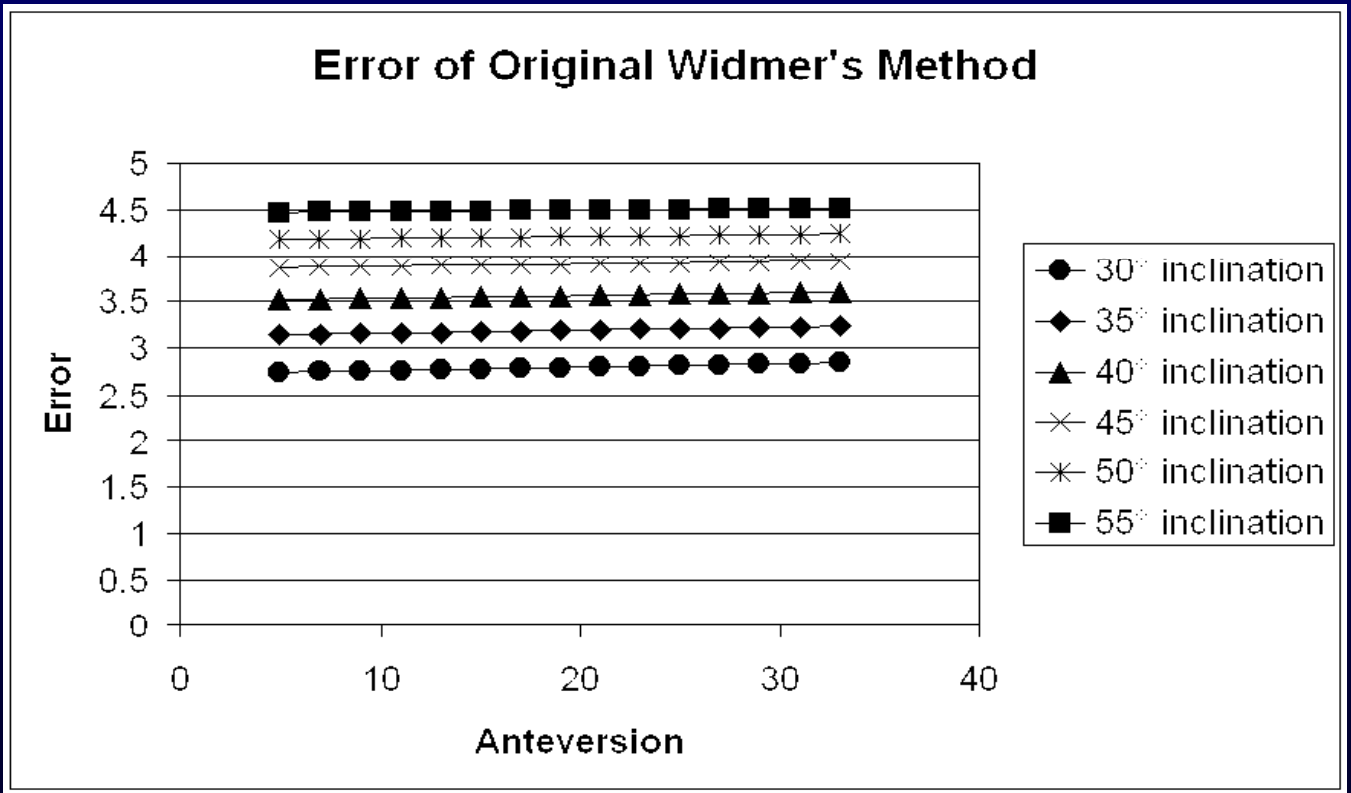
Methods

- We simulated 90 total hip arthroplasty radiographs with 15 different anteversions ranging from 5°–33° and six different inclinations (30°, 35°, 40°, 45°, 50°, 55°) using our simulation program.
- We use these two protractors to measure anteversions on these simulated radiographs.



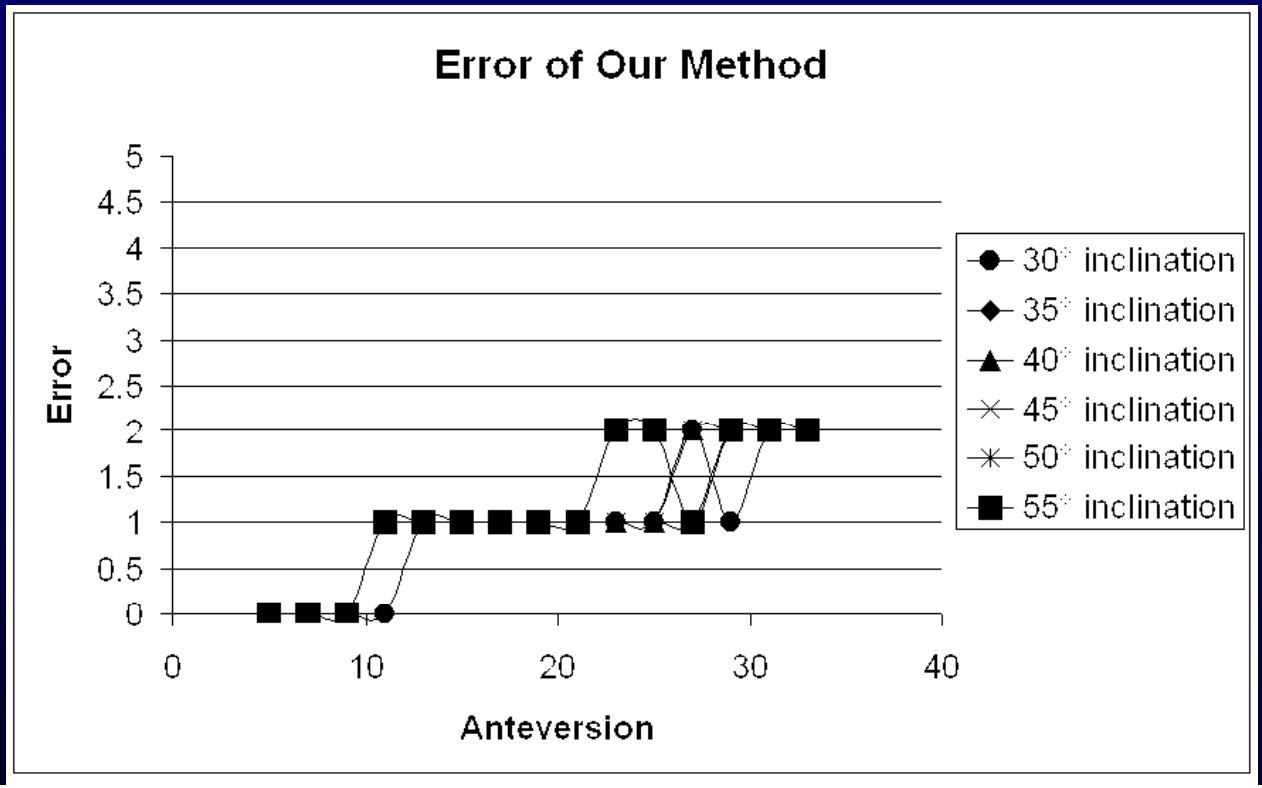
Results

- The error of Widmer's[12] protractor is $3.69 \pm 0.59^{\circ}$.



Results

- The error of Widmer's[12] protractor is $1.03 \pm 0.69^{\circ}$.



Results

- There is statistical difference between the two method ($p<0.01$).

Discussion


Poster & Scientific Exhibit
Our method (cont.)
Find center from the 200 detected edges
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
Check centers by "Hill-Climbing Search"[7]
Compare the two centers, and find the displacement vector.
Materials & Methods
Simulated data
64 simulated X-rays with 2 different anteversion angles, 2 different abduction angles, 4 different superior wears, and 4 different medial wears.
We measured these simulated X-rays automatically by our "Auto PE Wear Meter" program.
The results are compared.
Real X-rays
Real X-rays (Cont.)
There is no exclusion criteria of digitalization.
Results classification :
Wrong detection on cross-correlation
Wrong detection of acetabulum
Wrong detection of head
Minor error on acetabular center estimation
Minor error on head center estimation
Unmeasurable X-ray by Livermore's method
Partially measurable X-ray, which can be measured by other method
Measurable X-ray by Livermore's method
Results
Simulated data
-Our program can detect 61 of 64 simulated X-rays without misdetection (fig.
-The three mis-d rays were due misdetection acetabulum
The error on measuring
Real X-rays
47 excellent detections
2 unknown errors
3 wrong detections on cross-correlation (fig. 8)
23 wrong detections of acetabulum (fig. 9)
2 wrong detections of head (fig.10)
10 minor errors on acetabular center estimation (fig. 11)
0 error on head center estimation
19 unmeasurable X-rays by Livermore's method (fig. 12)
49 partially measurable X-rays, which can be measured with instrument (fig. 13)
2 measurable X-rays by Livermore's method (fig. 14)
2 X-rays measurable by program but unmeasurable manually
27 X-rays measurable by program but unmeasurable by Livermore's method
24 X-rays measurable manually but unmeasurable by program
X-rays measurable
Discussion
Conclusion
We developed a program which can automatically measure prosthetic wear. We have tested simulated X-rays and the results are encouraging. Clinical validation is needed in the near
Reference
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