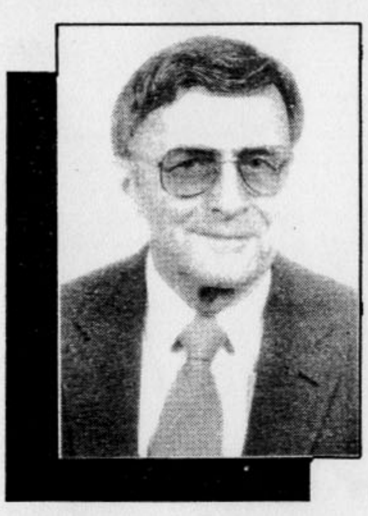
Guest Column

Using Inclinometers for X-ray Measurements

A Medical Doctor's Point of View, Part II



by John J. Gerhardt, M.D.

Dr. John Gerhardt graduated from high school in 1938 in Nowy Sacz, Poland and subsequently attended Polytechnic in Lwow, Poland. He studied medicine at the University of Berlin, Germany, Prague, and Graz, Austria, receiving his MD degree in 1948 in Graz. He became a certified orthopaedic surgeon in 1956 and immigrated to the United States in July of the same year. He had a family practice in Prophetstown, Illinois for 7 years before taking a full residency in physical medicine and rehabilitation at the VA Hospital, Portland, Oregon. After serving two years as research and education associate at the VA Hospital in Portland and Oregon Health Sciences University, he became chief of the Depart of Physiatry (Physical Medicine and Rehabilitation) at the Northwest Permanente Kaiser Health Care System in 1971. He retired from active practice in 1990. He serves currently as a consultant in PM&R at the Portland Shriners Hospital and the VA Hospital, Portland. He started a non-profit support group for amputees, Outreach Amputee Support Education Services, and engages in amputee care, rehabilitation, orthopedic medicine and orthopedic measurements. Has published papers and books on these subjects. Dr. Gerhardt is a member of the Board of Directors of the Washington State Spinal Institute.

In spite of improvements in clinical surface measurements of joint motion, especially in the spine, there is still a lack of precision and consistency in using external anatomical landmarks. Therefore, if exact determination of joint motion or curvatures and angulations of the spine are needed, x-ray measurements have to be taken.

Using inclinometers rather than two arm goniometers or protractors can facilitate and greatly increase the speed of measurements taken on x-ray films. Certain conditions, however, have to be met.

1. X-rays for evaluation of the spine must be taken in standing or weight bearing position to be meaningful.
2. The floor in front of the cassette holders must be level. This can be accomplished by either special platforms or self-leveling concrete.
3. The cassette holder must be level and solidly attached to the wall or adjustable frame. The best way to provide a gravity reference is a metal plumbline such as a piano string placed in front of the cassette or embedded permanently in a radiolucent plate, such as wood or plastic, which is attached to the cassette holder. This allows direct readings of many measurements on the dial of the inclinometer which indicates gravity.
4. The x-ray must be taken in at least two planes for accurate diagnosis of most conditions. For diagnosis of ligamentous injuries, stress x-rays may be needed.
5. X-rays should be of diagnostic quality and films with faulty exposure (grossly under- or over-exposed films) should be rejected. Proper labels with name and date, side indicators, and radiation protection shields should not cover up the areas which are to be measured to avoid repetition of x-rays and more patient exposure to radiation.
6. X-rays for orthotic and prosthetic problems should be ordered by specialists treating these conditions to avoid unnecessary "routine" x-rays.

(See Fig. 1)

The inclinometer can be attached to the diagnostic imaging x-ray scale which is transparent and long enough to bridge both hips or iliac crests on x-ray films. The scale has rulers in centimeters and inches, a protractor, multi-diameter templates for measuring congruence of joints (such as the hip joint) and a special scale with large gradations to allow exact measurements of small angulation. The scale combined with the inclinometer allows direct, accurate and rapid readings of most measurements on x-ray films such as scoliosis, kyphosis, lordosis, angular and linear deviations in fractures, dislocations and metabolic neoplastic or congenital lesions. Level of hips, the sacral base, and the lumbosacral angle can be read directly.

(See Fig. 2 & 3)

EXAMPLES OF MEASURING USING INCLINOMETERS WITH DIAGNOSTIC IMAGING (X-RAY SCALE):

Measuring Cobb's Scoliosis Angles

In measuring COBB's scoliosis angle with the conventional method, four construction lines and measuring of an angle are necessary, which is not only time consuming, but also gives five potential sources of error.

(See Fig. 4 & 5)

In using the inclinometer with attachment scale only two steps are necessary. The scale is aligned with the lower endplate of the lower neutral vertebra, the inclinometer is zeroed and then moved to the upper endplate of the upper neutral vertebra. The COBB's scoliosis angle is read directly on the dial. No construction lines are necessary.

The lower neutral vertebra of a scoliosis is the one with the disc below it wider on the concave side and narrower on the convex side. The disc above is wider on the convex side and narrower on the concave side. *(See Fig. 6).*

The upper neutral vertebra has the disc below it wider on the convex side and narrower on the concave side. The disc above is wider on the concave side and narrower on the convex side.

Similar considerations are applied to measurement of kyphosis and lordosis.

MEASURING ALIGNMENT OF THE CERVICAL SPINE

Measuring of abnormalities in the cervical spine such as a kyphotic curve (kink) and other deformities can be measured similarly.

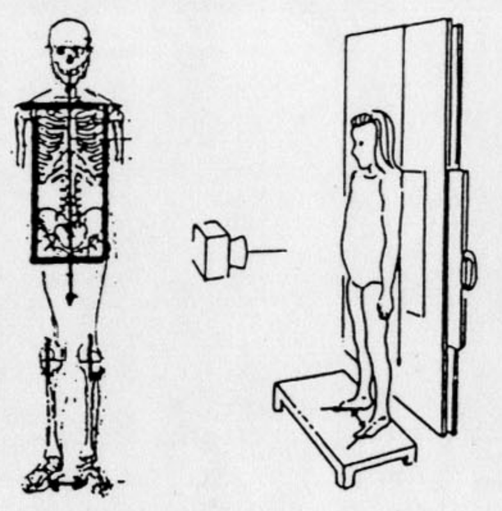
(See Fig. 7 on following page).

MEASURING FERGUSON'S LUMBO SACRAL ANGLE

The x-ray scale with the inclinometer is aligned with the margin of the film if it was taken properly or visible (radiopaque) plumbline to insure vertical positioning of the film. The scale is then aligned with

see "INCLINOMETER" on next page

X-ray Technique



For accurate assessment of the spine order x-rays of: full spine with hips, AP and lateral, standing on level floor or platform, with feet at hip width in 20 degrees external rotation, knees locked, and radio-opaque plumbline in front of the film cassette. Use 36" (91.4 cm) cassette lengths.

FIG. 1.

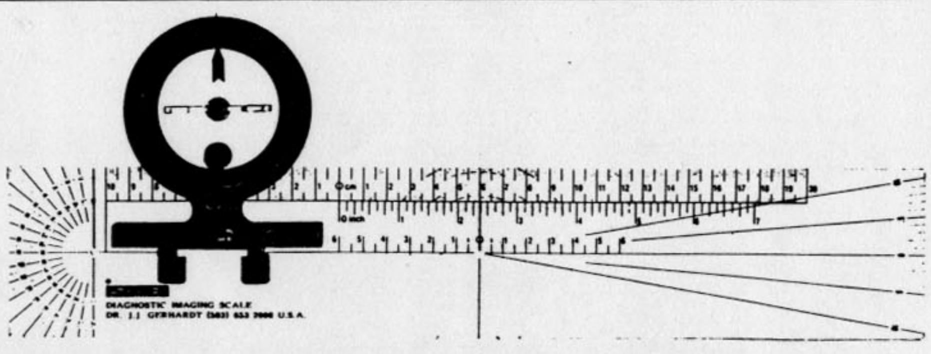


FIG. 2 Unilevel Inclinometer with Diagnostic Imaging Scale Attached

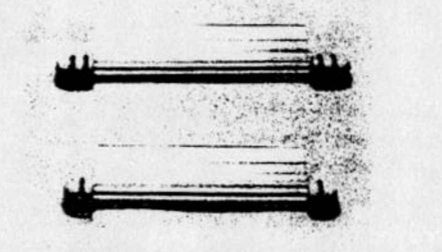


FIG. 3 Detachable rollers with rubber tracks allowing parallel gliding of the scale on the film without scratching it

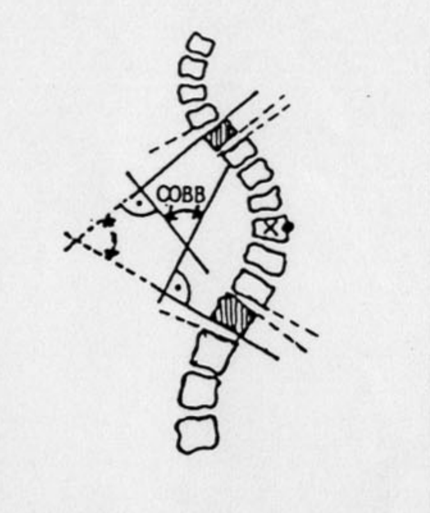


FIG. 4 Conventional Construction Lines for Determination of COBB's Scoliosis Angle in Dextro-Scoliosis of the Thoracic Spine

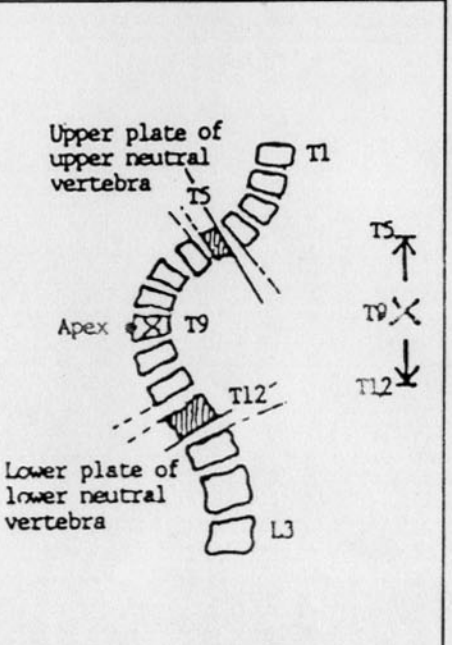


FIG. 6 Assessment of Neutral Vertebrae in Levo-Scoliosis T5-T12

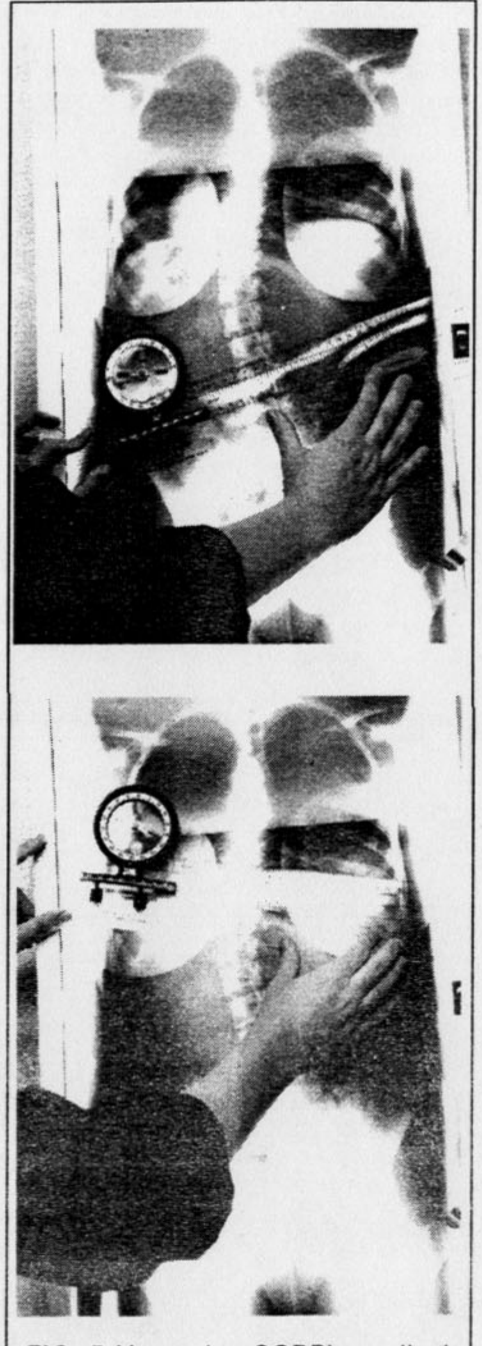


FIG. 5 Measuring COBB's scoliosis angle using inclinometer

INCLINOMETERS

continued from previous page

the upper endplate of S1 and the lumbosacral angle is read directly on the dial. (The lumbosacral angle is the angle between S1 and the horizontal.) *(See Fig. 8 and 9.)*

MEASURING SPONDYLOLISTHESIS

Two methods can be used: Meschan's lines connect the posterior cranial and caudal margins of L5. The scale is aligned and zeroed. Then the scale is aligned with the posterior caudal margin of L4 and posterior cranial margin of S1 and the angle for spondylolisthesis read on the dial. In true spondylolisthesis the lines intersect above the fifth lumbar vertebra. The angle up to 10° indicates slight, from 10 to 20° moderate, and over 20° severe spondylolisthesis. *(See Fig. 11)*

The second method is the Ullmann's line. The mid horizontal line of the scale is aligned with the cranial surface of S1 with the perpendicular midline aligned at the anterior line of S1. This line will transect the L5 vertebra in true spondylolisthesis. The distance of the sliding can be measured in centimeters and the grade of the spondylolisthesis determined. In another way of measuring the inclinometer is zeroed, while the scale is aligned with the upper surface of S1 and the scale is rotated at the anterior edge of S1 until the inclinometer shows 90° (Ullman's line). Grade I spondylolisthesis is when L5 is sliding anteriorly up to one-fourth of its width over S1, Grade II is sliding up to half the vertebral width, Grade III three-fourths, and Grade IV full width. *(See Fig. 12).*

MEASURING PELVIC TILT

The inclinometer indicates horizontal position of the scale. The scale is connecting the posterior superior iliac spine with the cranial anterior edge of the symphysis pubis and the pelvic tilt is read directly on the dial. *(See Fig. 13.)*

MEASURING FEMORAL NECK ANGLE

The scale with the inclinometer is aligned with the long axis of the femur and the inclinometer is zeroed. Then, the scale is aligned with the axis of the femoral neck and the femoral angle read directly on the dial. *(See Fig. 14).*

MEASURING ANGULATIONS IN FRACTURES

The scale is aligned with the proximal fragment of the fractured bone and the incinometer is zeroed. Next, the scale is aligned with the distal fragment. The angulation is read directly on the dial. *(See Fig. 15).*

MEASUREMENT OF ANGULATIONS AND DEFORMITIES

Angulations and angles of other regions can also be measured accurately and quickly. For example: Conversion angle of long axes of talus and calcaneus in the lateral view of the foot, or diversion angle of the talus and calcaneus in the AP view, the hallux valgus angle, the metatarsus varus angle, or Böhler's tuber-calcaneus angle which is diminished, zero or reversed in various degrees of calcaneus fractures, and others can be measured in similar fashion.

(See Fig. 16, 17, 18, 19, 20, and 21).

DETERMINATION OF SHORTENING OF LOWER EXTREMITY

Shortening of lower extremity can also be determined by x-ray if x-ray has been taken in standing position with both knees locked. The scale is aligned with the top of the lower femoral head and horizontal line marked under the opposite femoral head. Then the scale is moved horizontally to the top of the higher femoral head, and a horizontal line is drawn. The distance between the two lines indicates the shortening of the extremity. *(See Fig. 22).*

For further x-ray measurements refer to other pertinent literature.

Special thanks to Beverly Harger, DC, Director of Clinical Radiology and Gary Smith, DC, Radiology Resident, Western States Chiropractic College, Portland, Oregon for their input, reviewing and editing the manuscript and assistance in taking photographs.

FIG. 7. Measuring alignment of the cervical spine. (Kyphotic curvature or kink)

FIG. 7a. Kyphotic "Kink" at C4, & C5

FIG. 7b. Improved physiological lordosis

Measuring Ferguson's lumbo sacral angle:

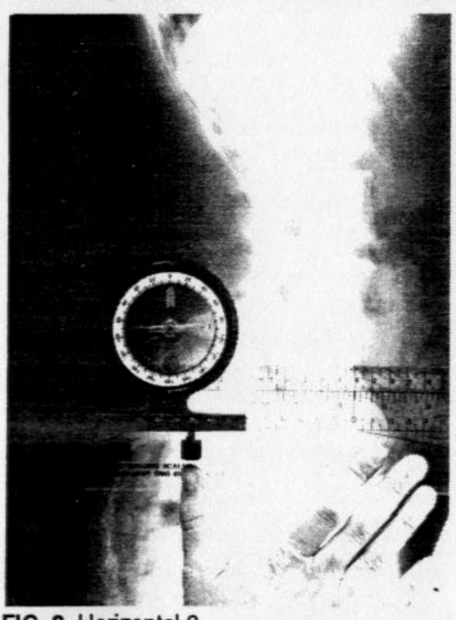


FIG. 8. Horizontal 0

FIG. 9. L5 angle

Measuring spondylolisthesis:

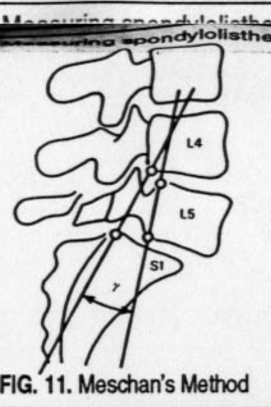


FIG. 11. Meschan's Method

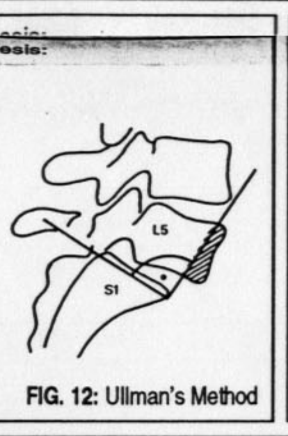


FIG. 12: Ullman's Method

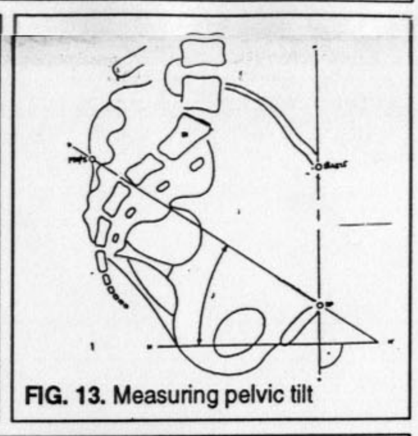


FIG. 13. Measuring pelvic tilt

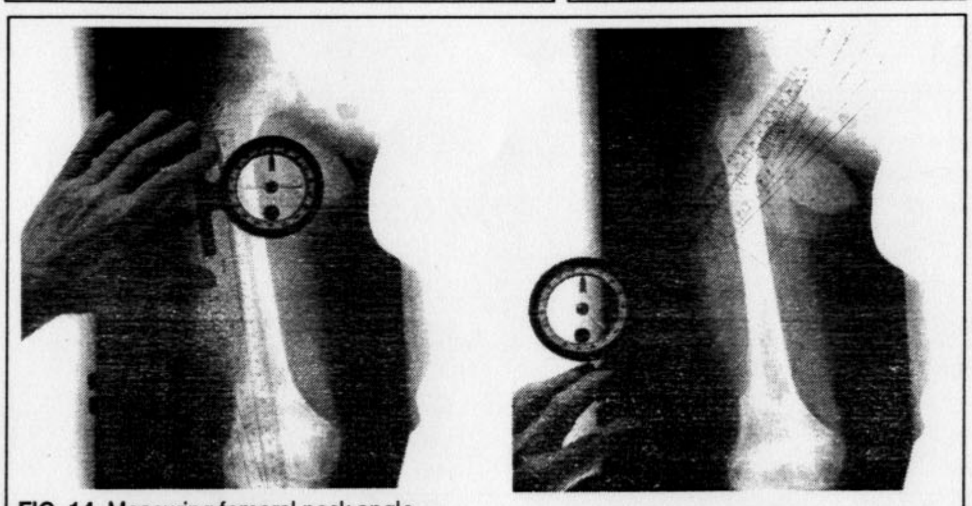


FIG. 14. Measuring femoral neck angle

FIG. 15. Measuring angulation of fracture of ulna

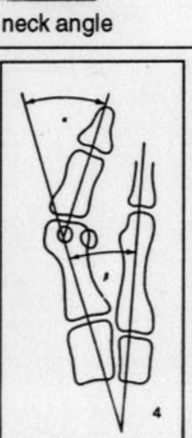


FIG. 16. Measuring hallux valgus. Measuring metatarsus I varus

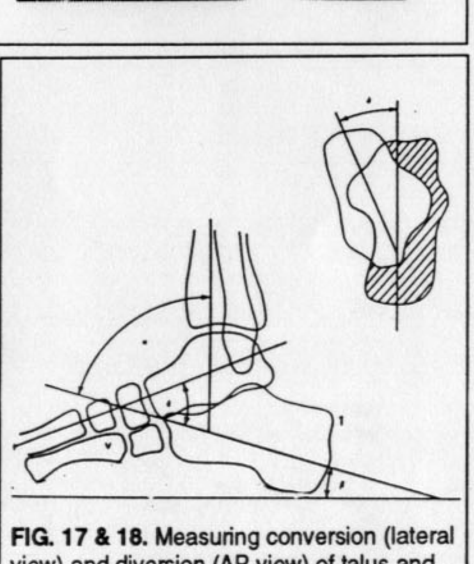


FIG. 17 & 18. Measuring conversion (lateral view) and diversion (AP view) of talus and calcaneus

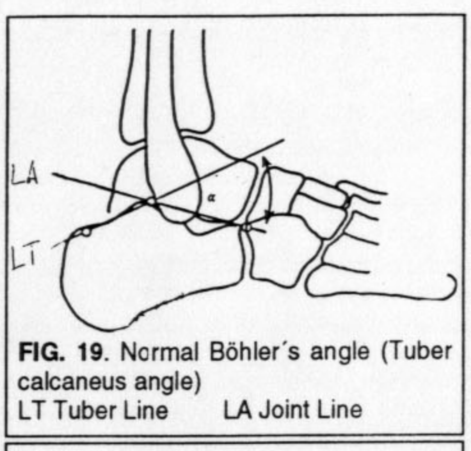


FIG. 19. Normal Böhler's angle (Tuber calcaneus angle)
LT Tuber Line LA Joint Line

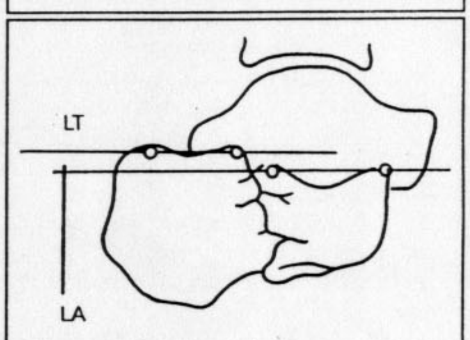


FIG. 20. Böhler's angle =0 (severe fracture)

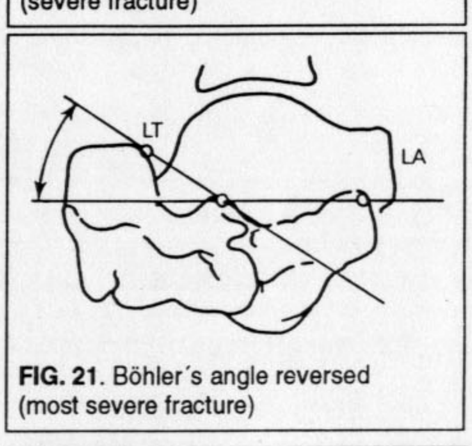


FIG. 21. Böhler's angle reversed (most severe fracture)

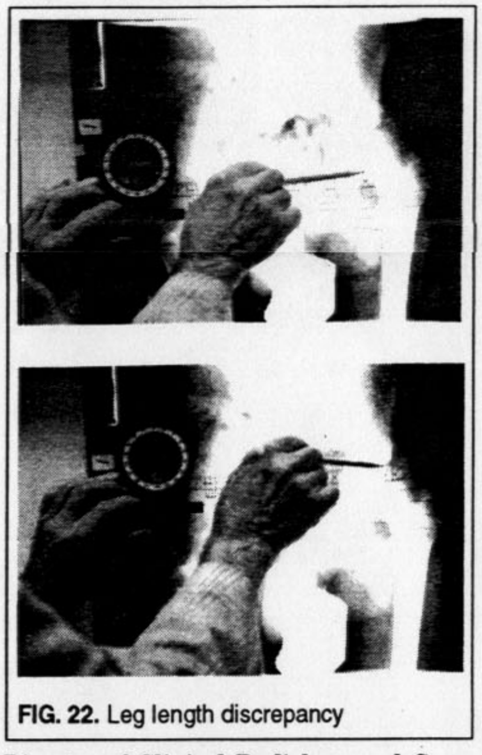


FIG. 22. Leg length discrepancy

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