

Objective

To determine the efficacy of a novel x-ray technology, DEI, for cartilage and other soft tissue imaging for the early diagnosis of arthritis and other degenerative joint diseases.

To optimize DEI for better imaging.

Why? Cartilage is invisible with conventional radiography (although MRI can show cartilage it required long imaging times, and because x-rays work through a different mechanism they may be expected to harness different tissue characteristics).

Arthritis

- Involves ~~pain~~, degeneration and inflammation of one or more joints.
- Can lead to total joint destruction
- There are actually several different forms of arthritis: rheumatoid, psoriatic, juvenile
 - Osteoarthritis – the hallmark is loss of cartilage

Osteoarthritis (OA)

- Over 40 million Americans suffer from symptomatic OA
- Before the age of 45 more men have it.
- After the age of 45 more women have it.
- Knee pain in older adults is reaching epidemic proportions!

CAUSES OF OSTEOARTHRITIS:

Internal factors



Genetics

Obesity

Shape of joints

External factors



Injury

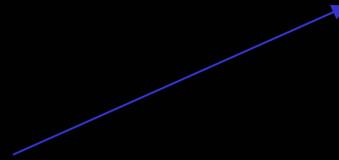
Stresses

Biomechanics (how the joint works)

Joints:

- Articular cartilage
- Muscles and tendons
- Subchondral bone

Synovial fluid





How Does DEI Work?

X-ray imaging technique best performed at a synchrotron with an intense, collimated source of tunable x-rays

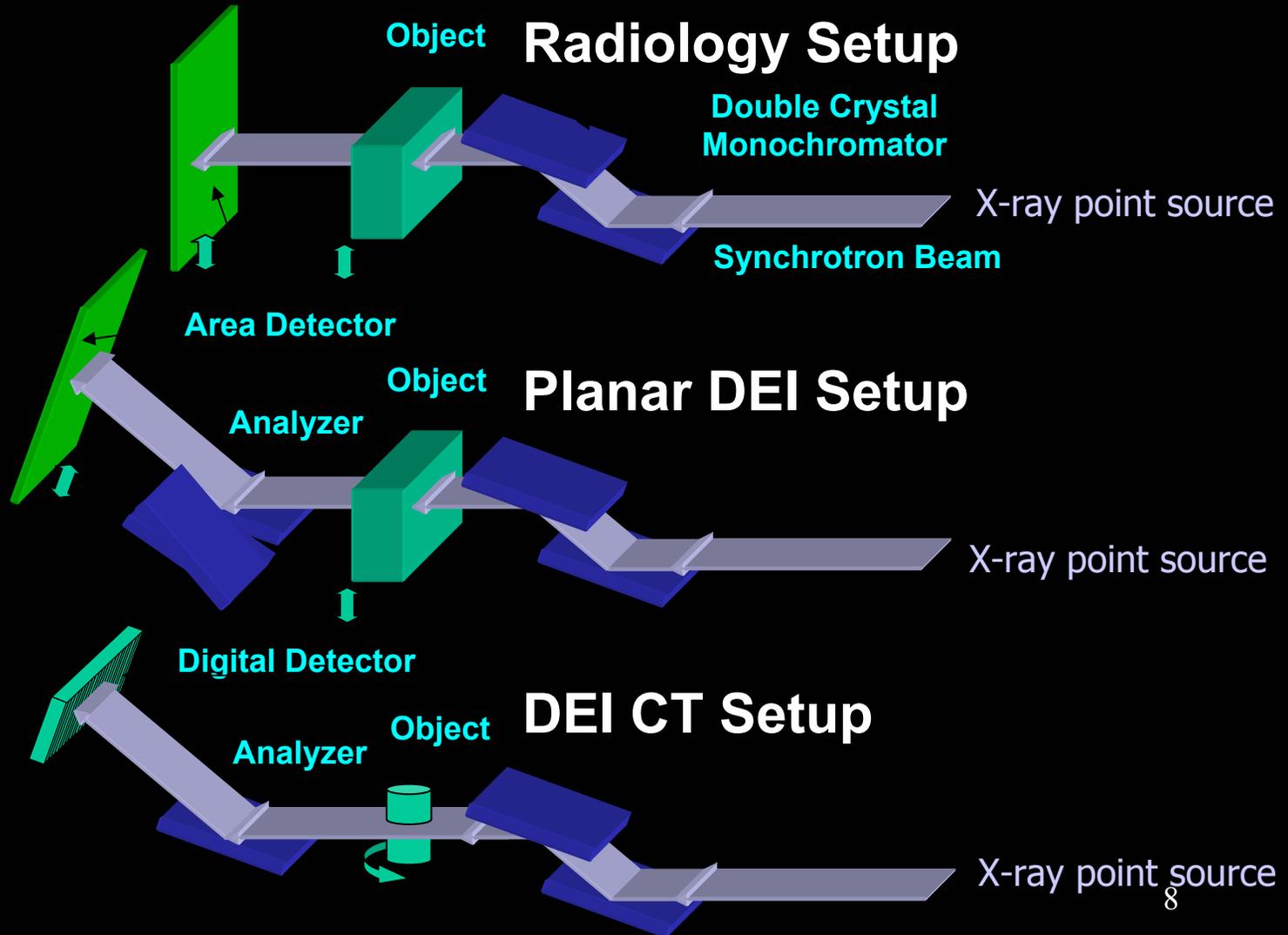
(there is currently no portable device that has high enough intensity)

Provides information on:

- absorption
- refraction
- scatter rejection

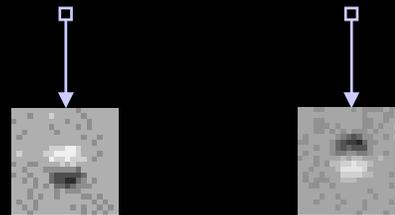
Comparable or lower x-ray dose than conventional radiography

Synchrotron Radiography and DEI

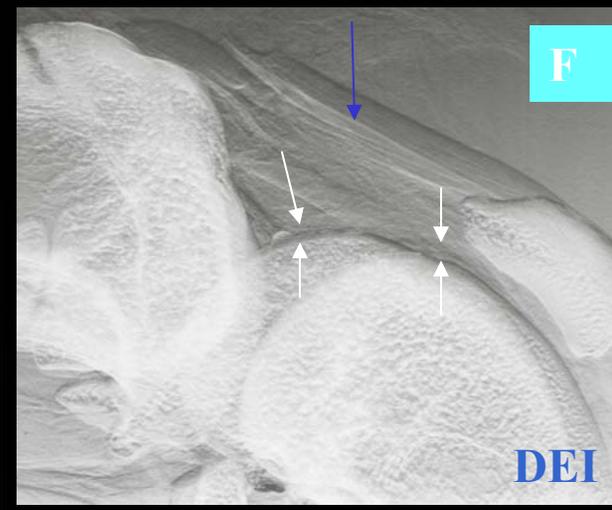
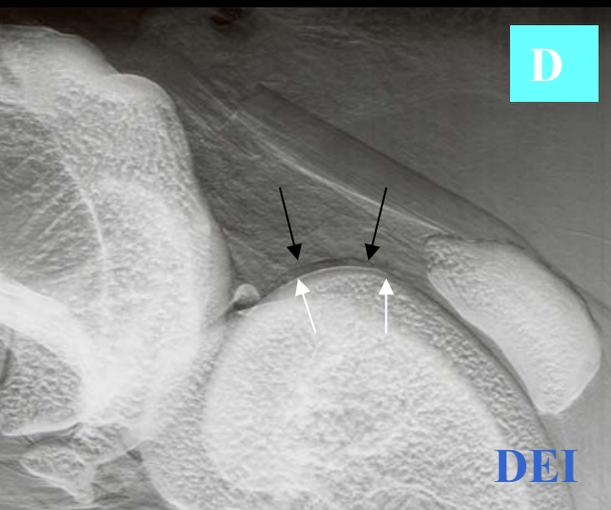
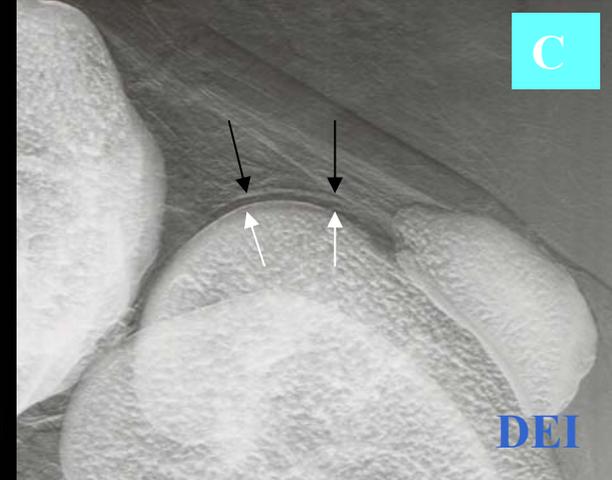
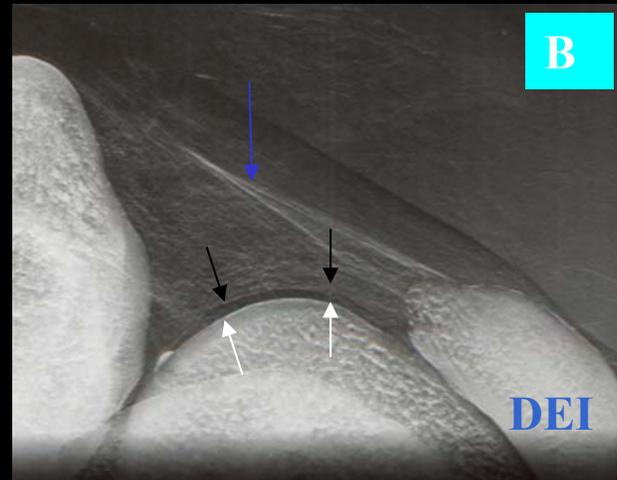
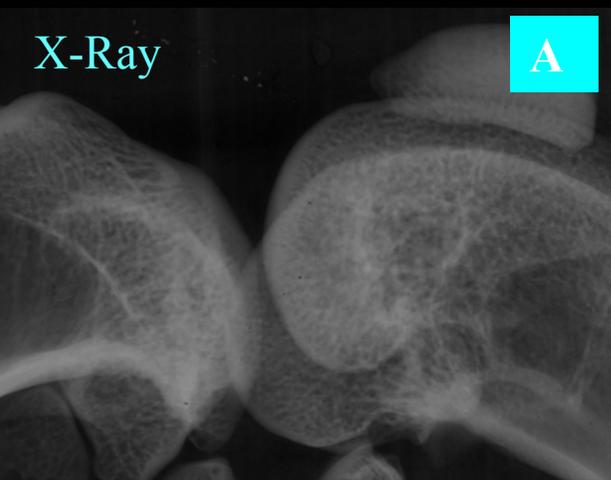


Two types of images:

- Images taken straight off the rocking curve
- Images that have been calculated (using an equation) by combining the 2 images from both sides of the rocking curve to calculate the mutual information and obtain the **apparent absorption image** and the **refraction image**.



DEI of an intact rabbit knee joint in a series of rotations

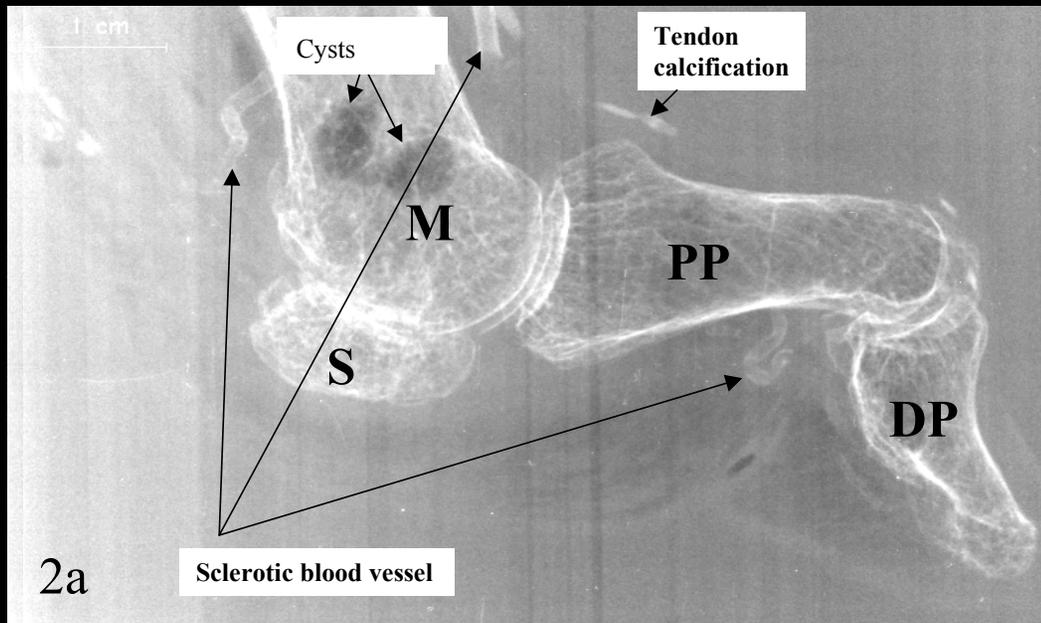




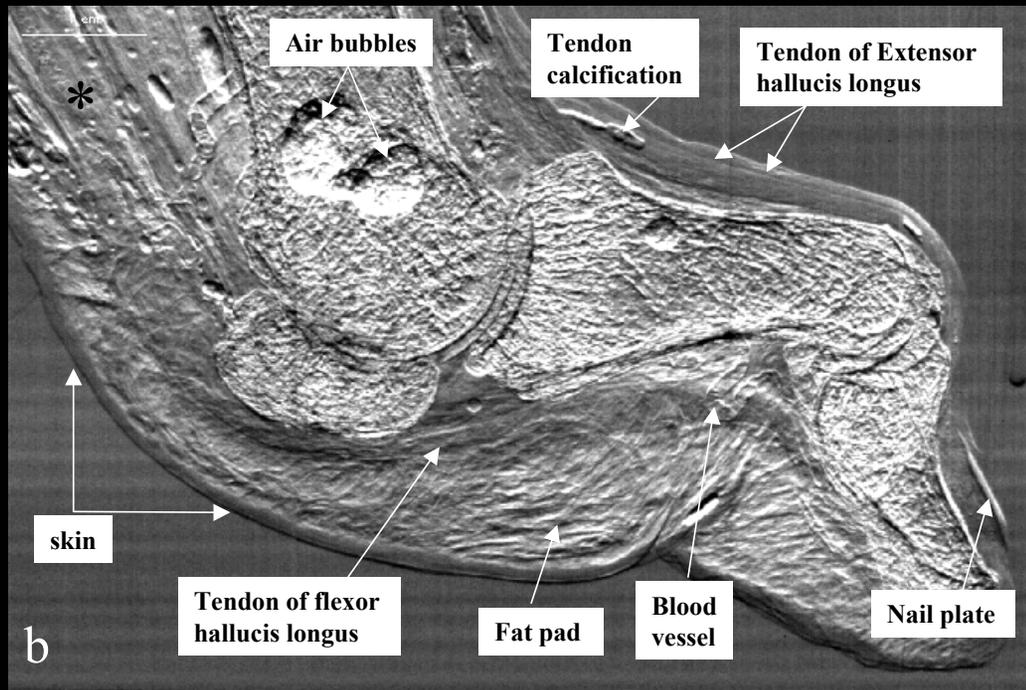
First application of DEI to soft tissues at sites other than knee and ankle:

- Fresh frozen whole human foot and several toes (at 40 keV)

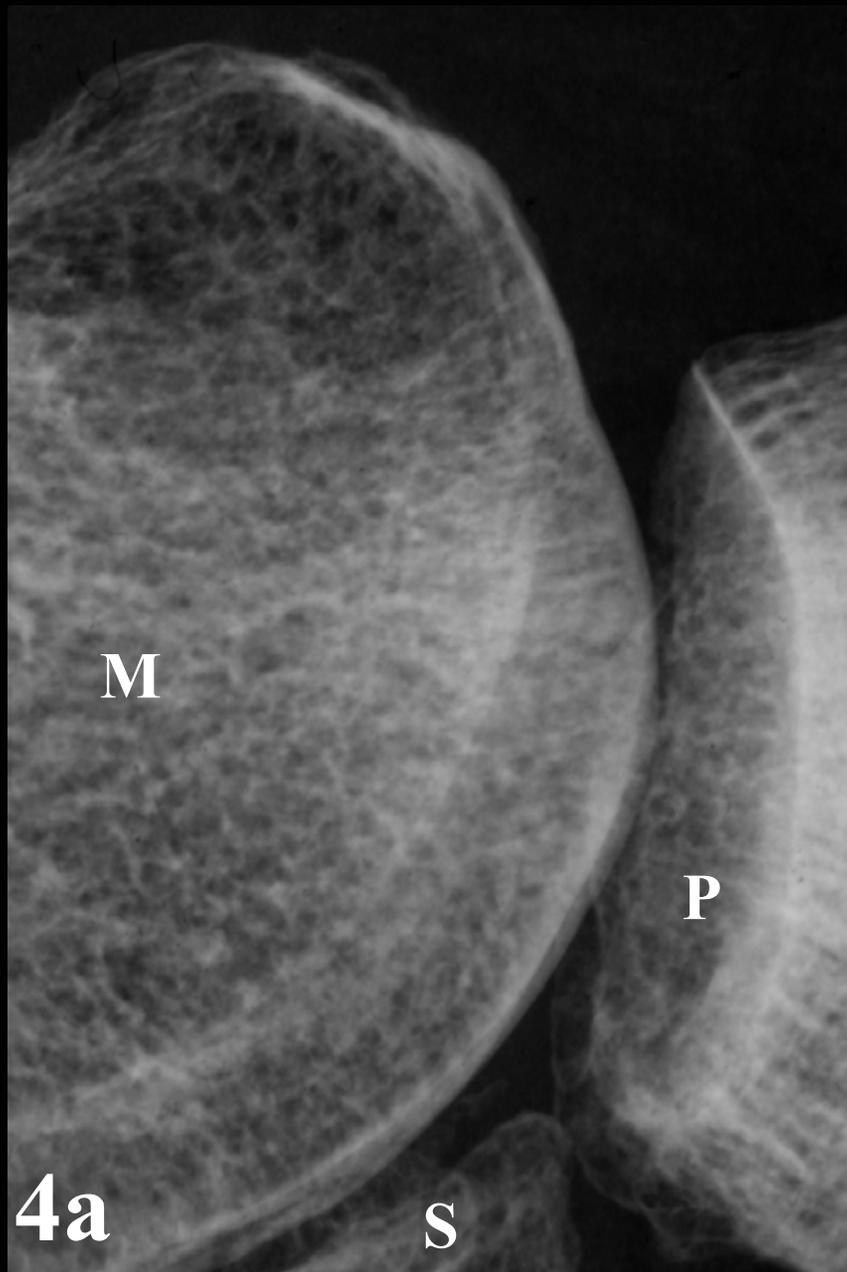
X-ray



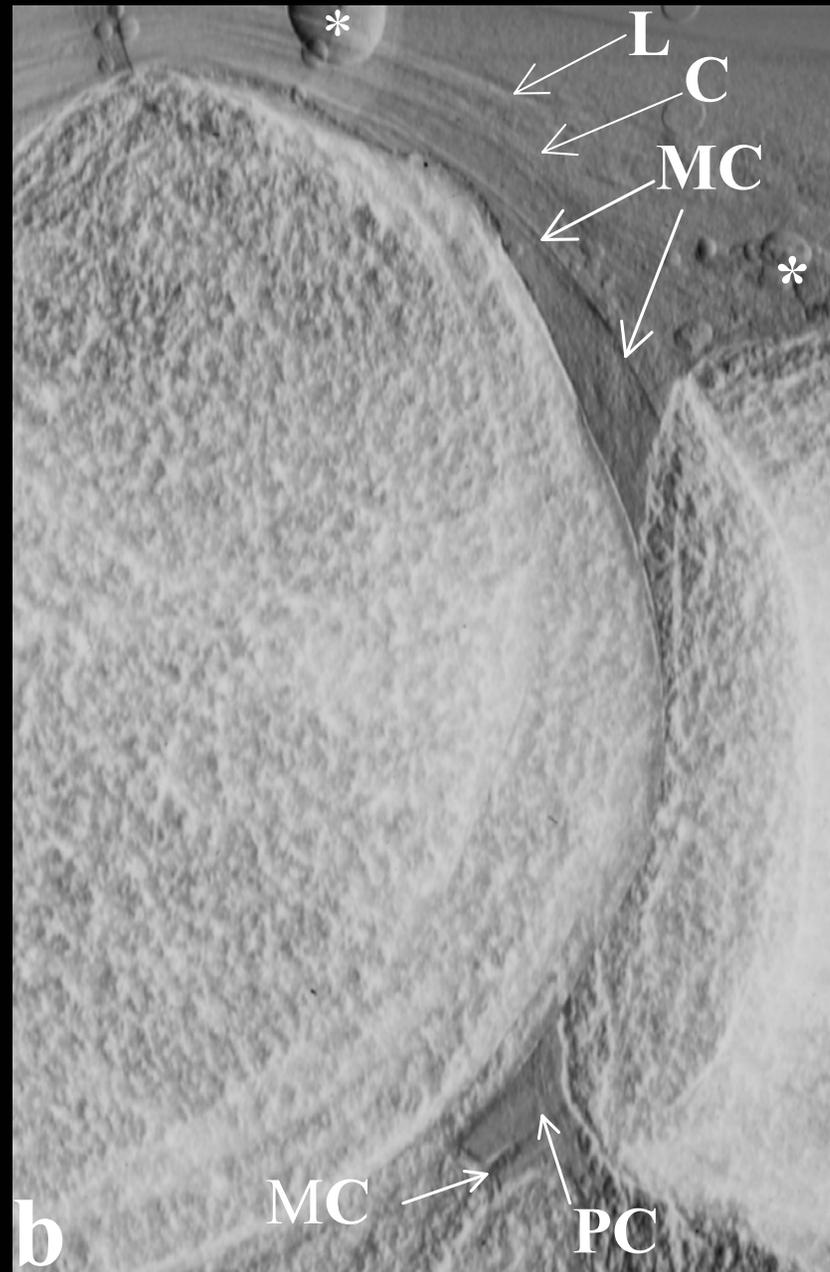
DEI

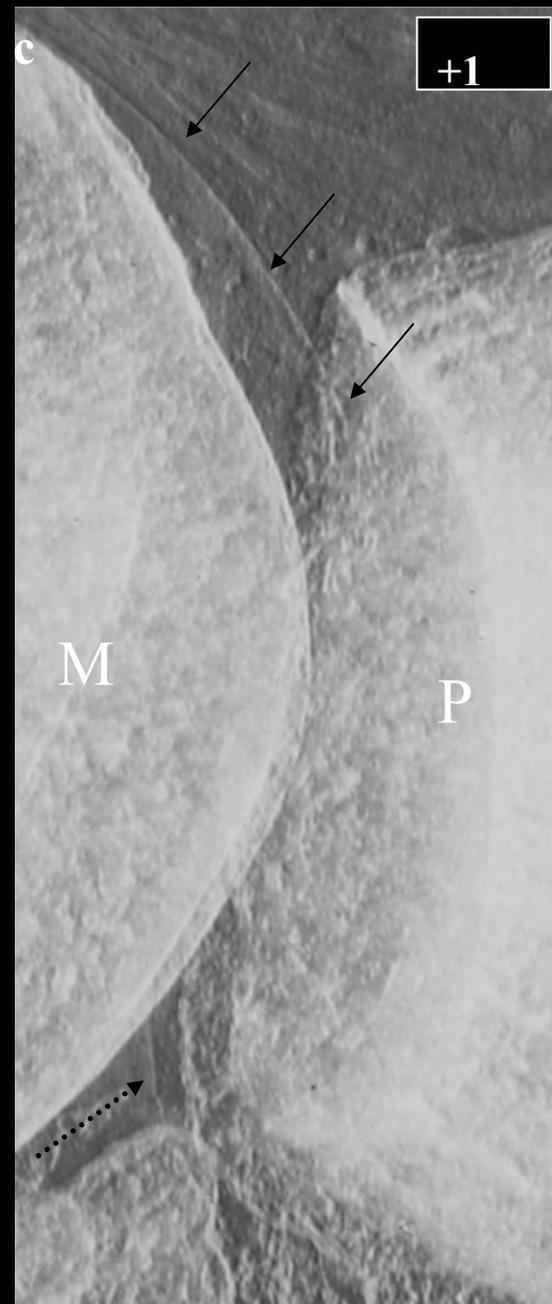
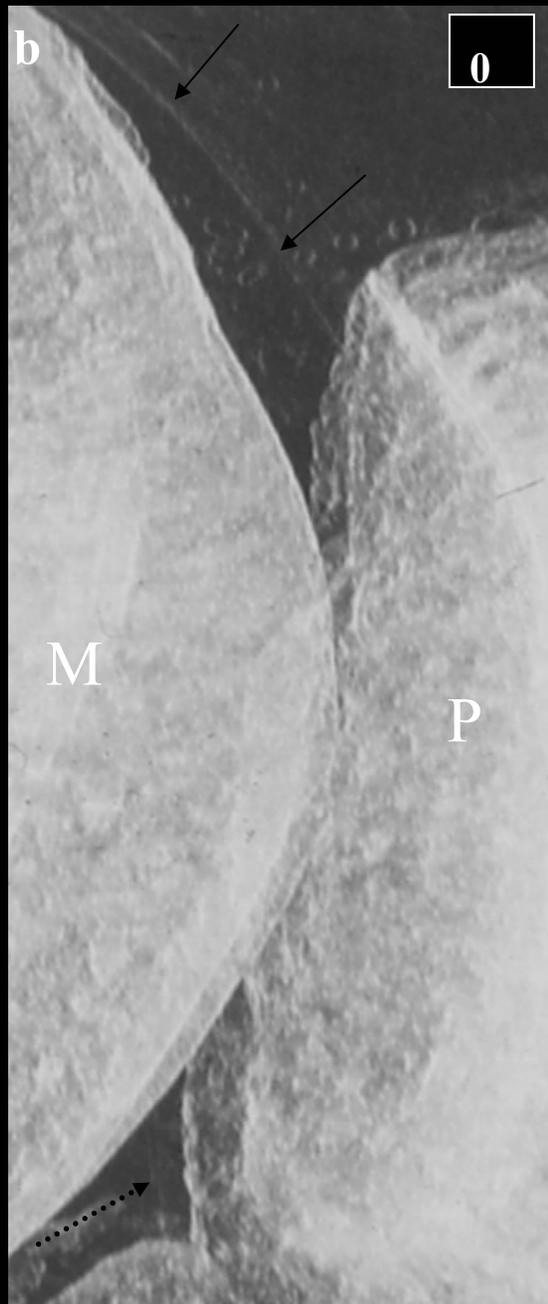
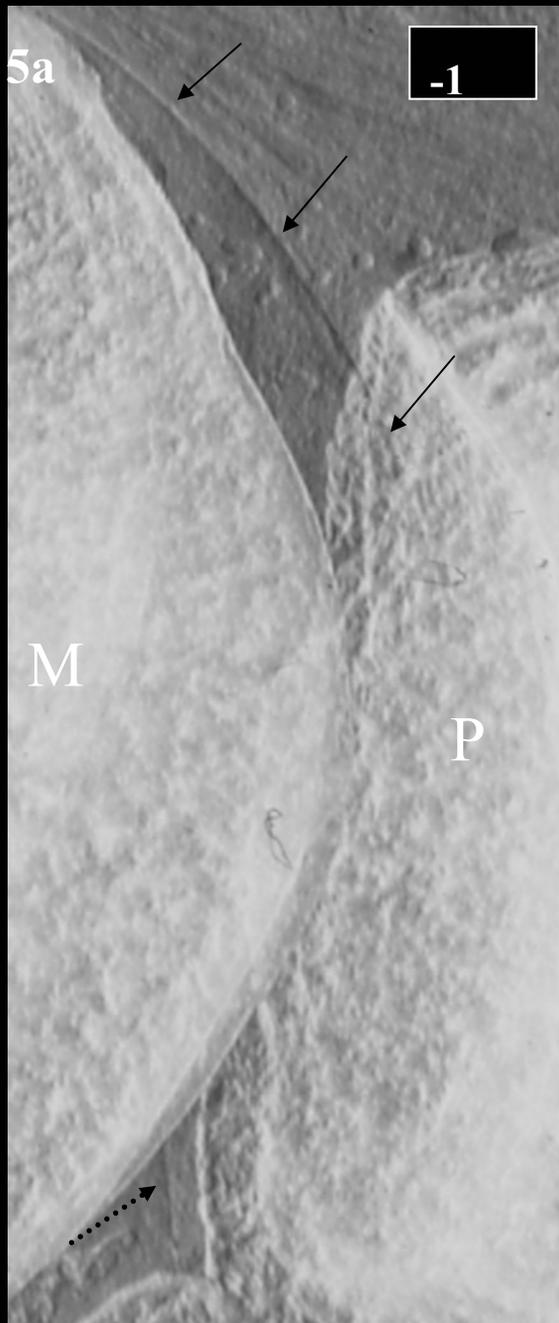


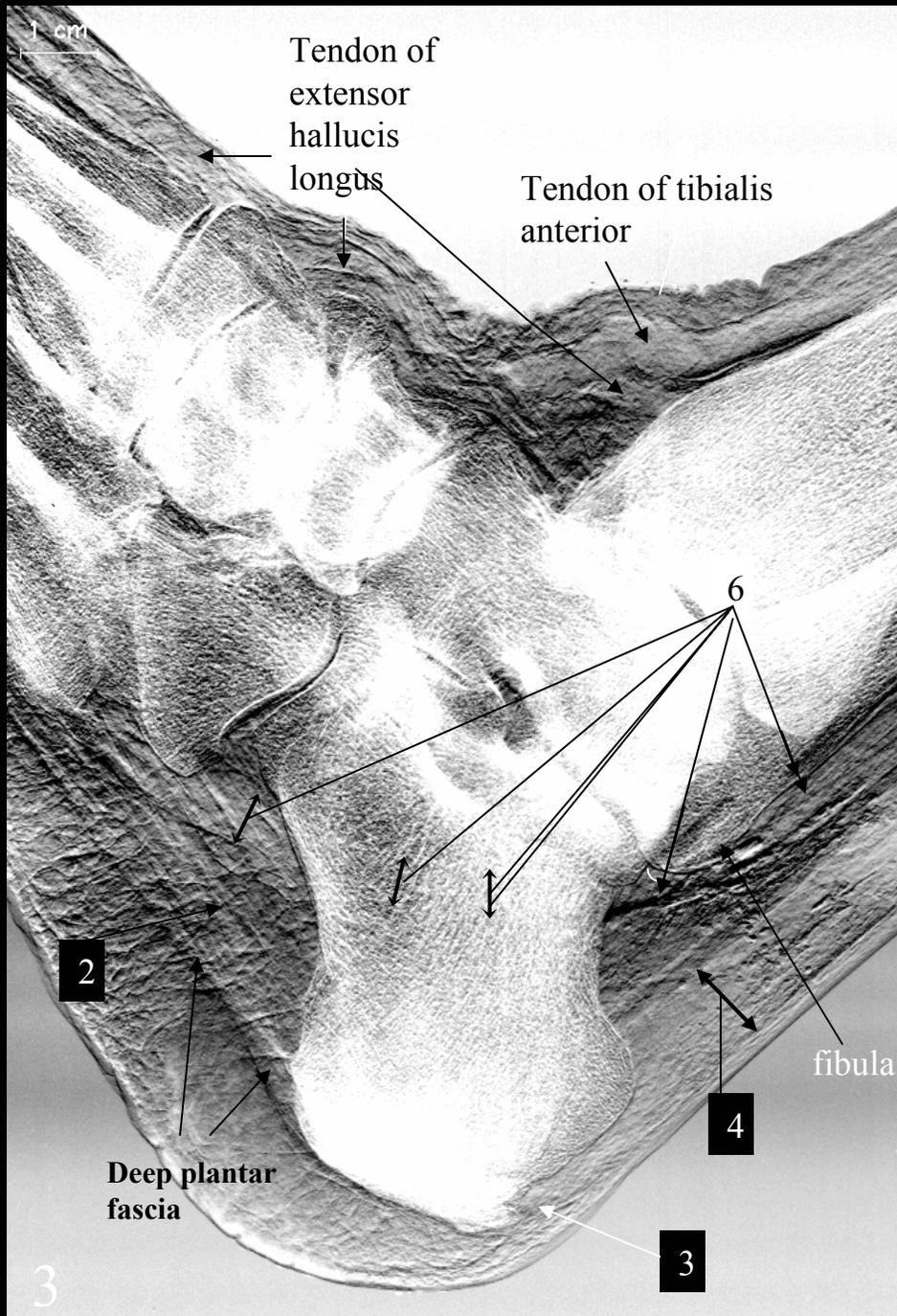
X-Ray



DEI







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5,5,5 harmonic
(as compared to 3,3,3
seen previously):
different crystal
lattice structure.

Current experiments:

Detection of cartilage defects in a dog model of cartilage damage.



Funding

- NIH #RO 1 AR 048292