



(Top) A knee joint of a patient with osteoarthritis. A significant amount of cartilage is lost. The joint space has narrowed, and the subchondral bone has thickened. (Middle) A comparison of conventional and synchrotron DEI X-ray images of cartilage in an osteoarthritic knee. (Bottom) An infrared image of the bone in an osteoarthritic knee joint.

Fast Facts

- 40 million Americans have osteoarthritis
- Osteoarthritis is the most disabling disease for people over age 65
- One million new patients develop arthritis each year. By the year 2020, an estimated 60 million people will have arthritis.
- Women accounted for 70% and people younger than 65 for approximately 26%.
- Estimates place the direct medical cost of arthritis at \$15.2 billion per year, with total costs of medical care and lost wages exceeding \$64 billion.
- Arthritis accounts for 427 million days of restricted activities, 156 million days in bed and 45 million workdays lost annually.

Sources: U.S. Centers for Disease Control and Prevention and the Thurston Arthritis Research Center.

Osteoarthritis

Introduction

Osteoarthritis (OA) is the most common type of arthritis, particularly in adults 65 years and older. OA is a degenerative disease that frequently leads to chronic pain and disability. With the aging of our population, this condition is becoming increasingly prevalent and its treatment increasingly financially burdensome. Currently, only the symptoms of OA can be treated; there is no cure. Therefore, understanding the causes of OA and finding better treatments are the major focuses of research at this time.

How is osteoarthritis diagnosed?

Osteoarthritis is characterized by breakdown of the joint cartilage, joint space narrowing, thickening of the underlying subchondral bone, and osteophyte formation. The pain in osteoarthritis arises from cartilage erosion; without the protective cartilage cushion in a joint, the joint space narrows and bones rub against each other. X-rays are considered the "gold standard" for diagnosing OA, but radiographic changes are evident only relatively late in the disease. Thus, there is a great need for an imaging method or biological marker that would enable early diagnosis of OA and monitor its progression.

What is BNL doing for to understand and diagnose OA?

Researchers at BNL are using a new form of x-ray imaging called Diffraction Enhanced Imaging (DEI) for earlier diagnosis of OA. DEI is used to image the joint cartilage human knees and ankle joints. The high contrast and resolution of this technique provide a more detailed image of the joint cartilage. This technology is also being used for breast cancer treatment.

Other scientists at BNL are using infrared light to study the causes of OA. Recent studies on monkeys have shown that the bony bed underneath the joint cartilage thickens prior to cartilage breakdown. Thus, it is suspected that over-mineralization of that (subchondral) bone may be an important factor in the development and progression of OA.

How is synchrotron light used?

At the NSLS, synchrotron x-ray light and special X-ray optics are used to produce diffraction-enhanced images of the cartilage in

osteoarthritic knees. The DEI method uses a single-energy (monochromatic) fan beam of X-rays instead of the broad-energy beam used in conventional imaging. The object is scanned through the beam. The key to the new imaging method is an analyzer crystal placed between the object and the X-ray detector. The analyzer can differentiate between X-rays that are traveling much less than one ten thousandth of a degree apart. This method of line scan imaging reduces scatter and helps to visualize low-contrast areas that otherwise would be lost.

Also at the NSLS, infrared light is used to study the chemical composition of bone in monkeys with OA. Using an infrared microscope, an intense beam of infrared light is focused through a very small sample of bone. Scientists are using this technique to image the subchondral bone, which is the layer of bone underneath the joint cartilage. Studies have shown that this layer of bone becomes highly mineralized in early OA. It is thought that this condition may influence joint cartilage breakdown in the disease.

How will this research help the OA patients in the future?

The high contrast images obtained from DEI imaging of joint cartilage has the potential to revolutionize the use of x-rays in the diagnosis of osteoarthritis. DEI has the ability to allow distinction between the normal and degenerated cartilage in much earlier stages of the disease. In addition, infrared imaging of the subchondral bone in OA will help provide an understanding of how bone composition affects the development and progression of OA, hopefully one day leading to methods of prevention and treatment of the disease.

For more information, you can contact:

Dr. Zhong Zhong
National Synchrotron Light Source
Brookhaven National Laboratory
Upton, NY 11973
Phone: (631) 344-2117
Email: zhong@bnl.gov

or
Dr. Lisa Miller
National Synchrotron Light Source
Brookhaven National Laboratory
Upton, NY 11973
Phone: (631) 344-2091
Email: lmill@bnl.gov