

Dura-Pearl Hip Implant

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Patient Profile

Name: Nyota Uhura

Age: 53

Weight: 54 kg

Sex: Female

- Suffered from pain in her feet for over 3 years, which spread to her hip over this time.
- Was prescribed anti-inflammatory drugs, however the effects wore off over time.

Symptoms:

- Stiffness in Thigh/Groin Area
- Swelling
- Discomfort
- Reduced Joint Spacing
- Bone Erosion
- Nodules on Feet

Our Diagnosis

Our Diagnosis: Rheumatoid Arthritis

- Chronic Inflammatory Disorder.
- Her symptoms correspond to rheumatoid arthritis.
- Several test results indicated her having the chronic disorder.

Rheumatoid Arthritis:

- An autoimmune disease - the patient's immune system attacks the cells which line their joints, resulting in swelling and inflammation.
- Over time, can result in damage to joints and/or the surrounding cartilage [1].

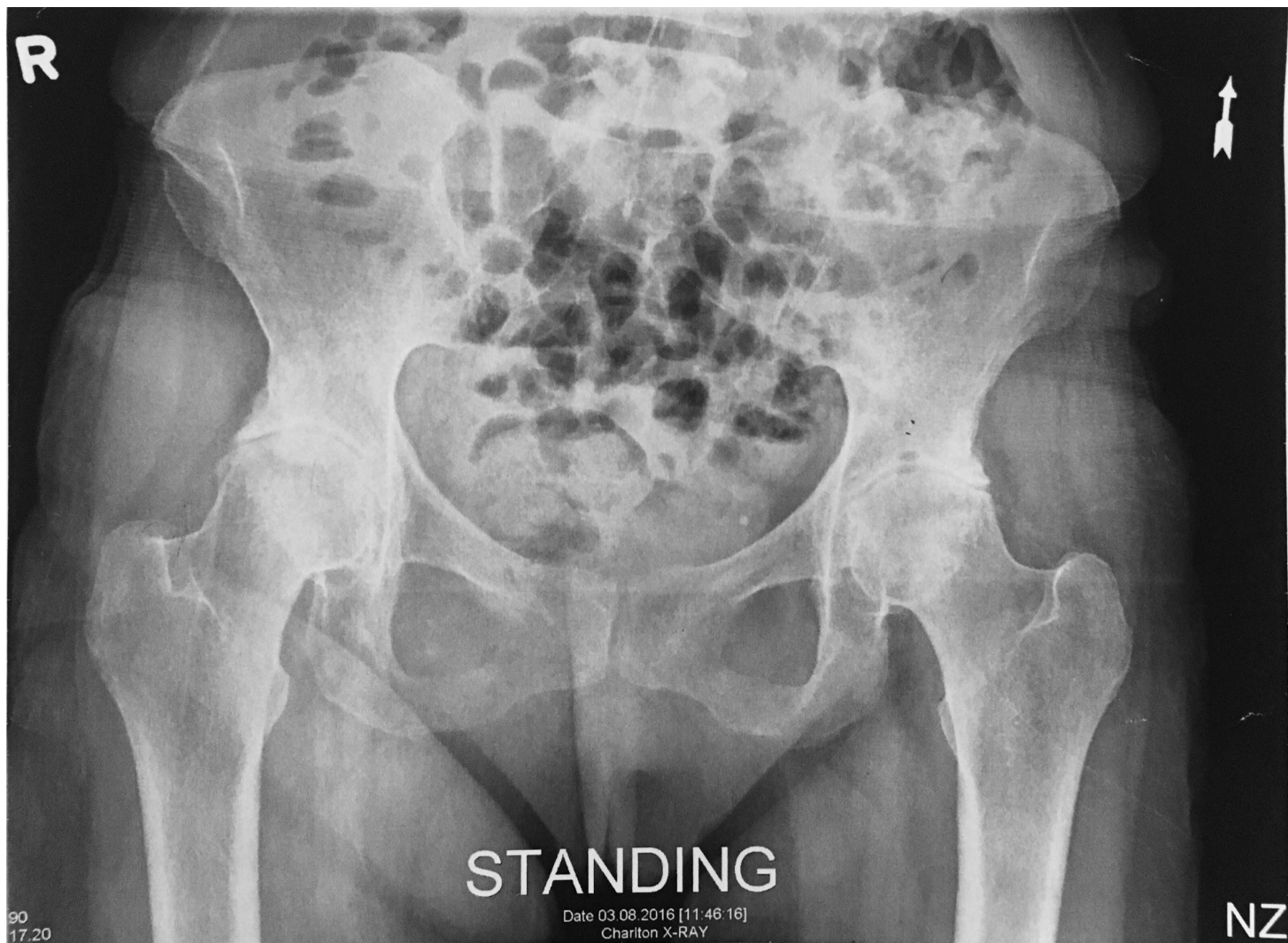


Figure 1. X-Ray scan of our patient, Nyota Uhura. Notice the symmetrical bone erosion and narrowed joint spacing on both hip joints.

Hip Resurfacing Arthroplasty

- An alternative method of hip replacement, which removes far less bone than a total hip replacement
 - Less invasive procedure with a faster recovery time
 - Reduces the possibility of stress shielding
 - More natural gait - especially important for young and active patients
 - Easier for future revision surgery[2,3]

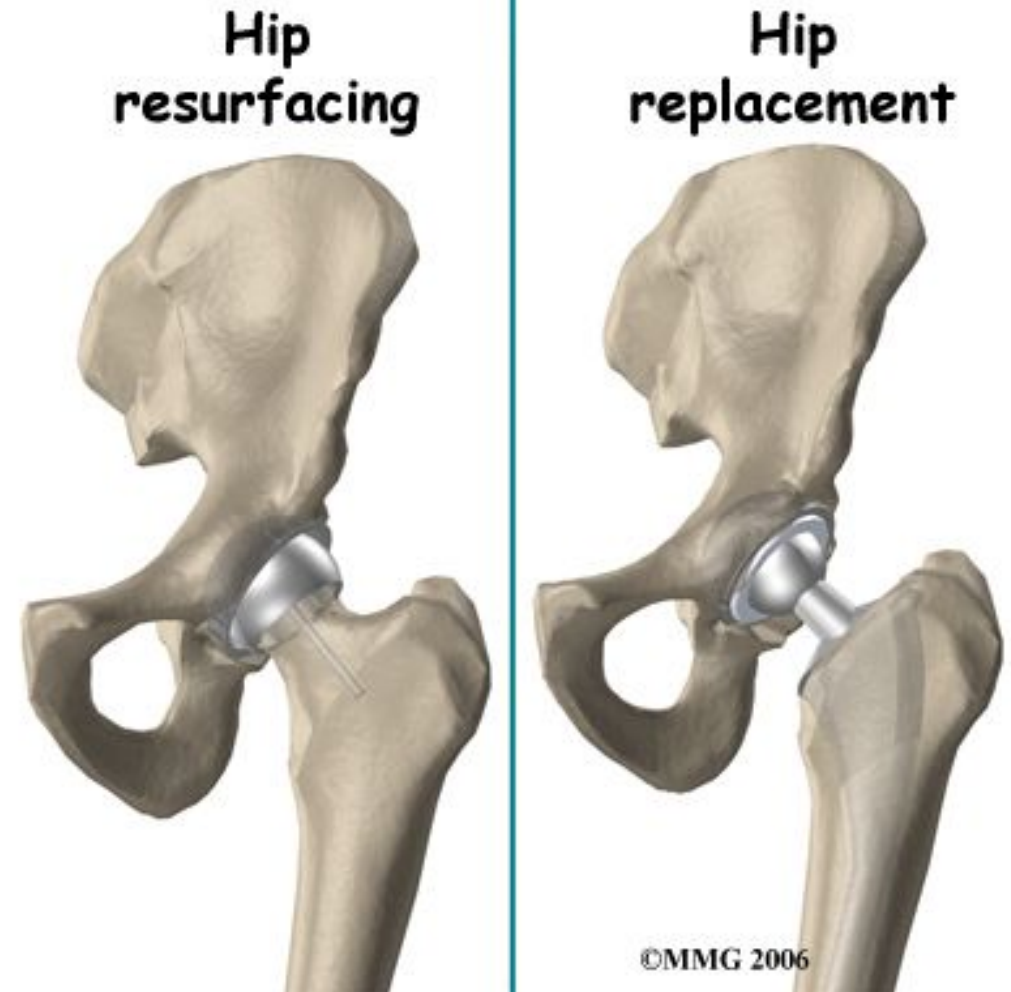


Figure 2. Illustrates a hip resurfacing implant on the left and a total hip replacement on the right.

Form and Function

Acetabular Cup

- The acetabular cup is the top piece of the hip implant, which integrates into the pelvis.
- Our acetabular cup has rings extruding from the outer surface to encourage osseointegration.
- Geometric shapes and alterations were limited on this piece to keep the material structurally stable and decrease the chance of fracture.
- The hole on top is for the acetabular cup to be screwed into the pelvis.

Femoral Head Cap

- The femoral head cap is placed on top of the femur after the bone is shaved down.

- The outer dimensions of this cap are measured to match the dimensions of our patients actual femoral head. This makes the replacement more natural for her body to adjust.
- Bumps on the inside of the cap encourage osseointegration and keep the cap from shifting.



Figure 3. 3D printed model of Dura-Pearl Hip Implant

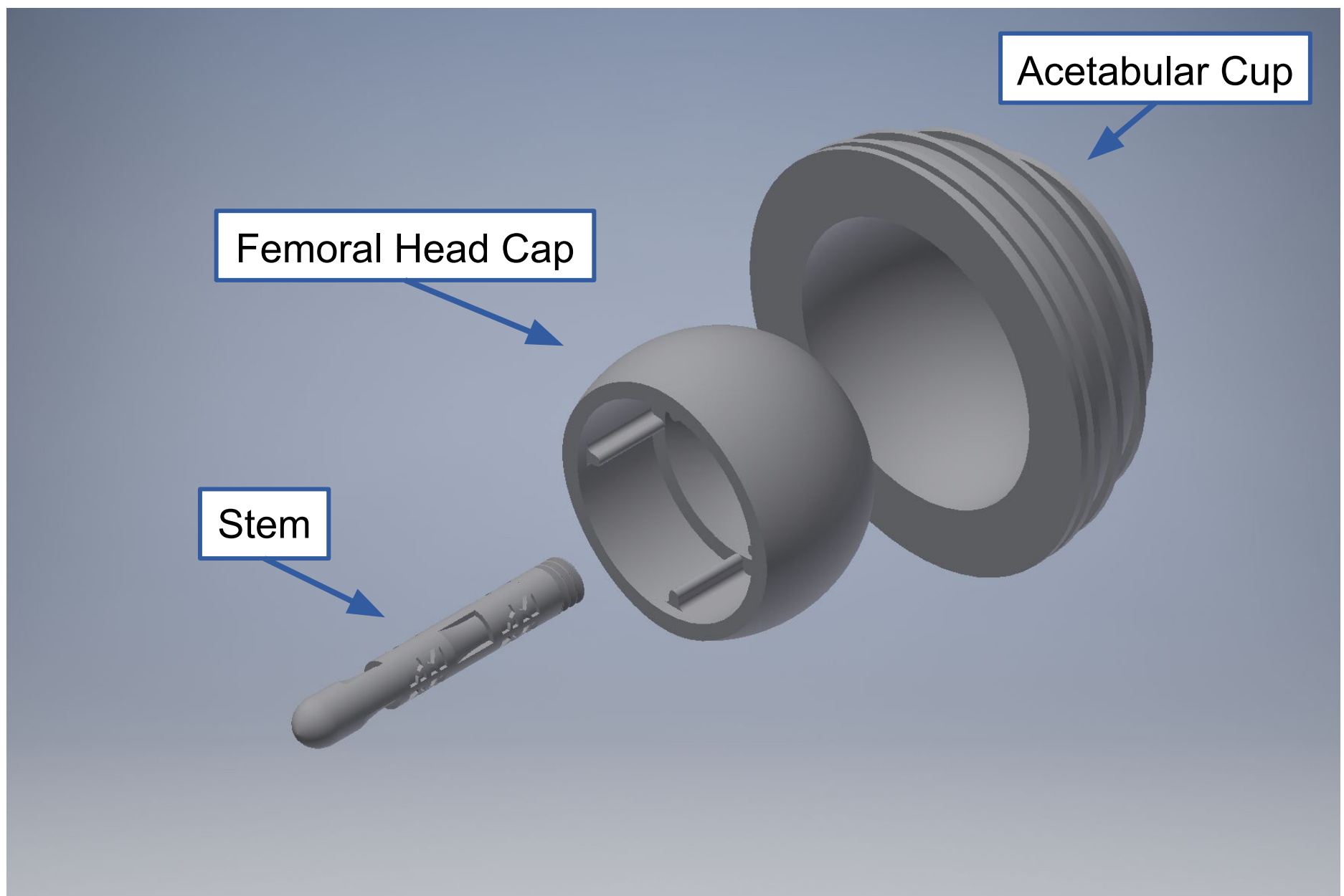


Figure 4. A CAD rendering of Dura-Pearl Hip Implant.

Dimensions

Stem:

Length: 44 mm

Diameter: 6.2 mm

Femoral Head Cap:

Inside Diameter: 28.5 mm

Outside Diameter: 37 mm

Acetabular Cup:

Inside Diameter: 37.1 mm

Outside Diameter: 54.1

Femoral Stem

- The femoral stem is inserted in the femur and attached to the femoral cap.
- The geometric protrusions and extrusions are added for osseointegration.
- The material used for the stem allows it to be 3D printed which makes the fine details possible.
- The small size of the stem of our implant means less stress shielding will happen in our patients bones, and make femoral fractures unlikely.

Materials Selection

Acetabular Cup and Femoral Cap

Polyethylene Glycol (PEG) - Nacre Composite

- Nacre has a unique “brick and mortar” structure which accounts for a high fracture strength.
- “Bricks” of aragonite (CaCO_3), are layered atop a biopolymer material; “the mortar”[4].
- Nacre is a bioactive material capable of promoting bone growth.
- PEG is dispersed throughout nacre's matrix. PEG acts to harden the composite and provides “non-fouling” benefits, which prevents bacteria from adhering [5].

Polylactic Acid (PLA)

- PLA is a bioactive degradable polymer
- Biodegradable PLA acts as a coating to the acetabular cup that is able to release remicade, an anti inflammatory drug, upon first implementation[6].

Stem

Polyether ether ketone (PEEK)

- PEEK is a semi-crystalline thermoplastic. It is an engineered biomaterial capable of producing bone growth and adhesion.
- PEEK is used as a filament in 3D printing to achieve the geometric shapes in stem piece, which further promotes integration with the femoral head [7].



Figure 7. PEEK is becoming an interest in the development of dental implants as a solution for patients with metal hypersensitivities.

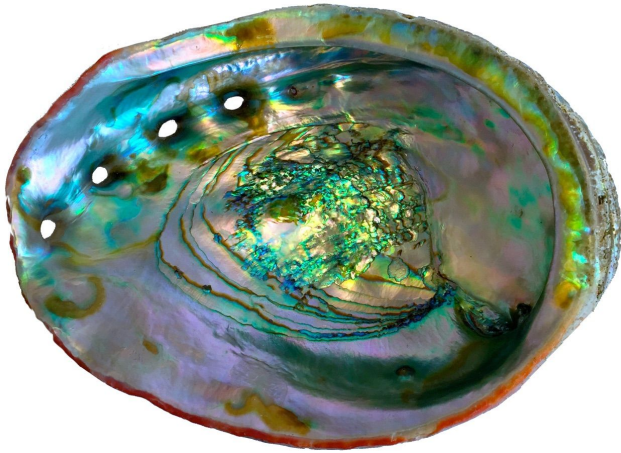


Figure 5. Nacre is a naturally occurring organic-inorganic composite synthesized by molluscs.

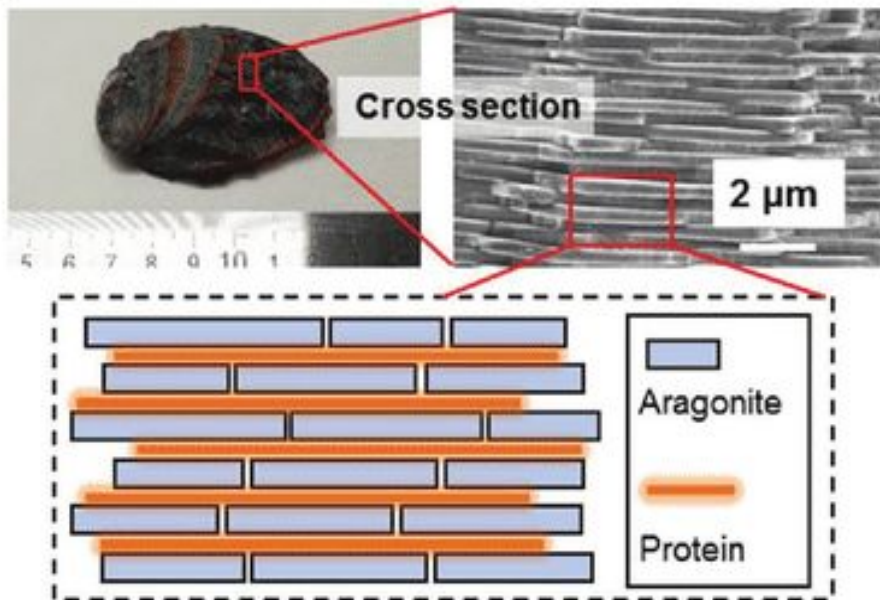


Figure 6. A cross section of Nacre shows the layering of Argonite and elastic polymers.

Method of Surgical Fixation

Cementless Hip Resurfacing

- With a cementless implant, the bone naturally integrates with the implant through osseointegration [8].
- Cementless implants are believed to offer a better long-term bond between the implant and bone [8].
- Avoids risks of cemented implants:
 - Breakdown of the cement can cause the artificial joint to come loose.
 - Cement debris can potentially enter the bloodstream.
 - Cement debris can irritate the surrounding soft tissue and cause inflammation [8].

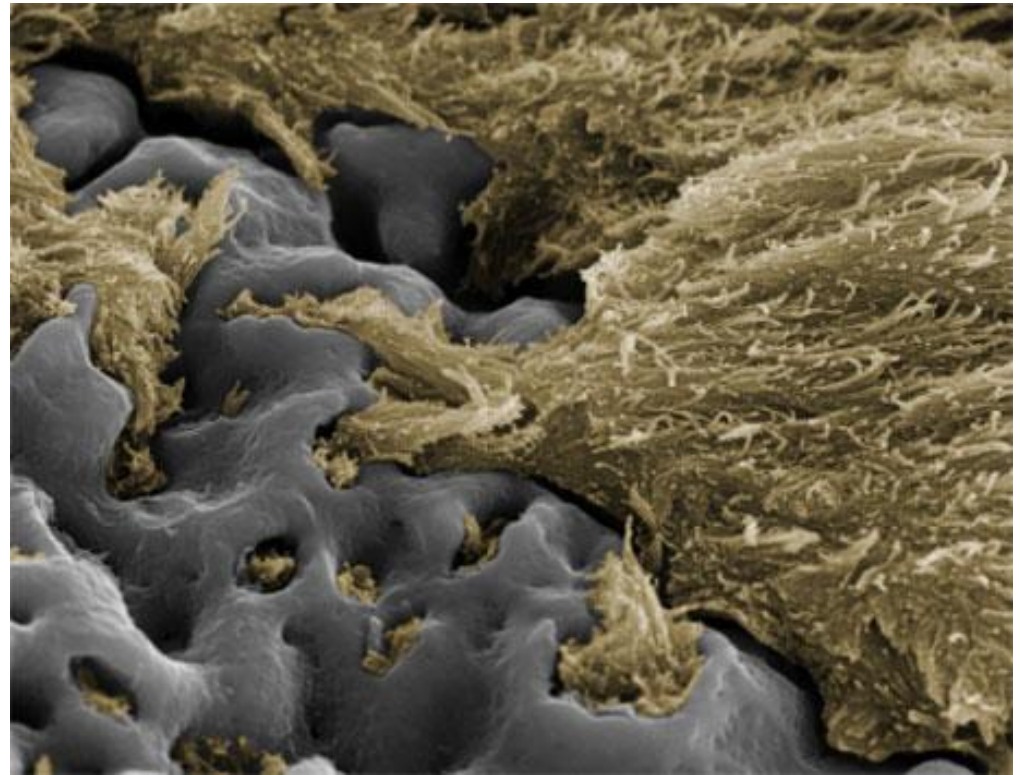


Figure 8. Osseointegration is occurring. Bone will naturally undergo this process on our implant.

In Summary

- The materials were strategically selected to encourage osseointegration, and reduce fracture risk of the implant or femur.
 - Nacre is a durable, bioactive material capable of promoting bone growth.
 - PEEK is also biocompatible with bone and has extremely high strength and stiffness.
- Despite our clients Rheumatoid arthritis, X-rays show no signs of bone loss.
 - Shows strong bones, meaning bone integration is not a concern [9].
 - We avoid removing healthy bone by doing a hip resurfacing rather than a total hip replacement.
- The cementless implant is beneficial for a longer-lasting bond.
- Inflammation is avoided and reduced:
 - The PLA coating releases an anti-inflammatory drug.
 - Using a cementless surgical fixation eliminates the possibility of inflammation caused by cement debris.

Why Dura-Pearl?

1

Innovative materials completely eliminate the use of metals.

2

The design and materials promote osseointegration.

3

The design reduces inflammation of the muscles surrounding the implant post-surgery.

Sources

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Figure 1:

Hip x-ray from McMaster University

Figure 2:

OrthoPod.com

Figure 5:

From University of Wisconsin-Madison

Figure 6:

From advanced Science.com

Figure 7:

From MedicalExpo eMagazine

Figure 8:

From Ordinacija Cvejanović Blog

