

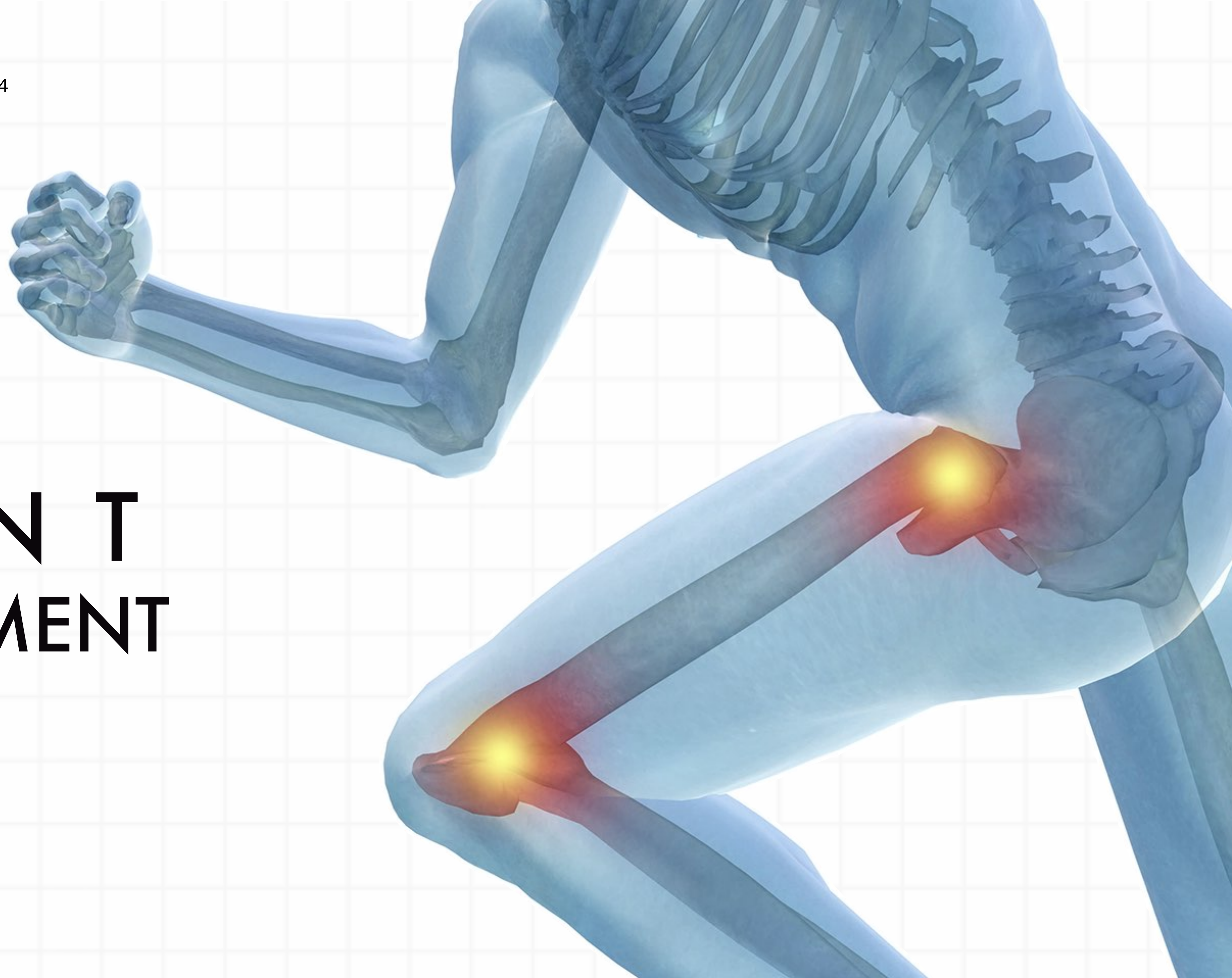
Emma Munck

//

November 21, 2024

Seminar in physiology
and instrumentation

JOINT REPLACEMENT



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joint replacement

Physiological aspects

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Product aspect

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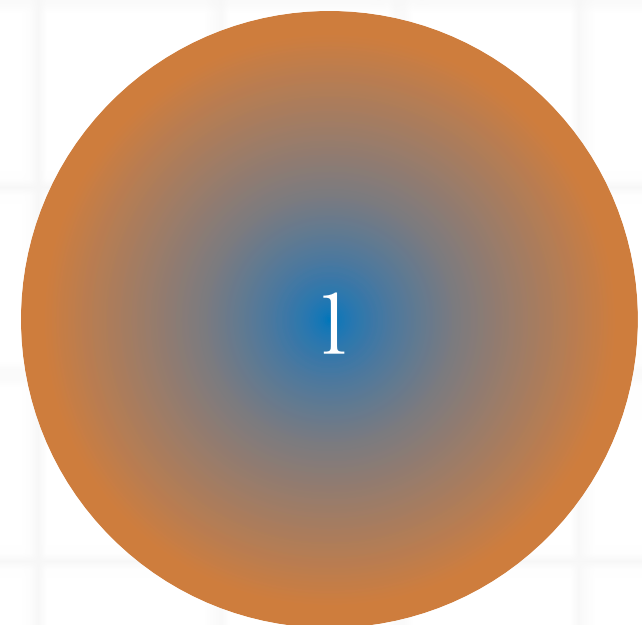
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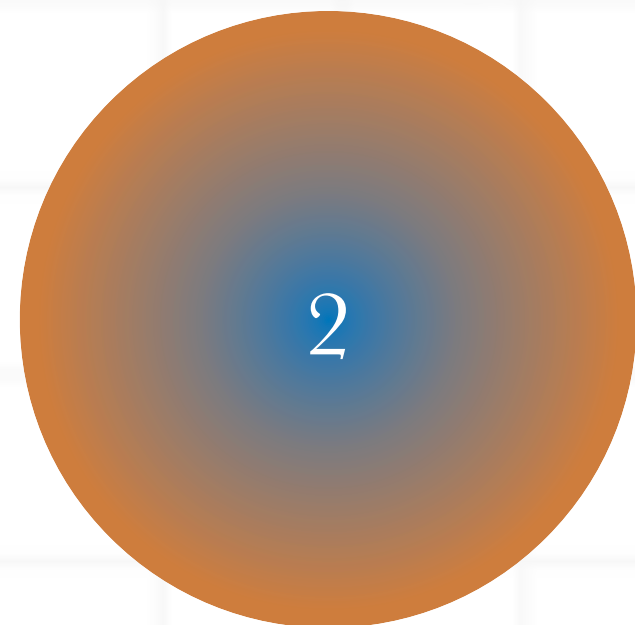
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[https://www.oecd-ilibrary.org/docserver/7a7afb35-en.pdf?
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B39335882F05C6C0ED](https://www.oecd-ilibrary.org/docserver/7a7afb35-en.pdf?expires=1732040733&id=id&accname=guest&checksum=80314D26C1E84DB39335882F05C6C0ED)

Summary

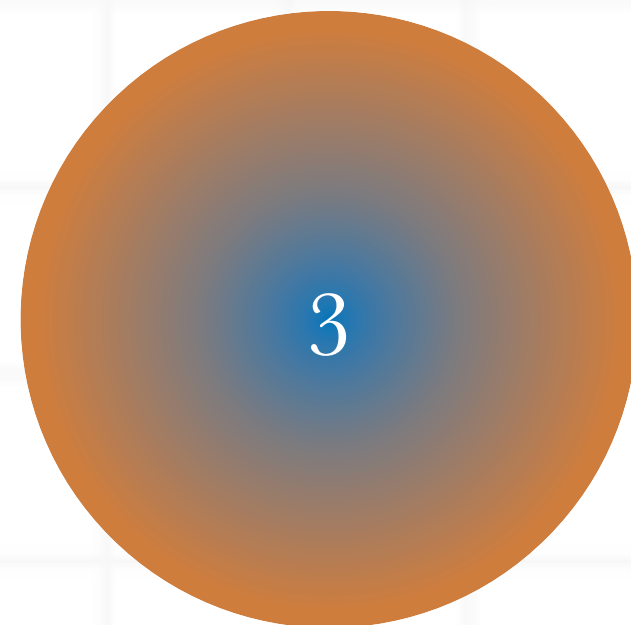
joint replacement



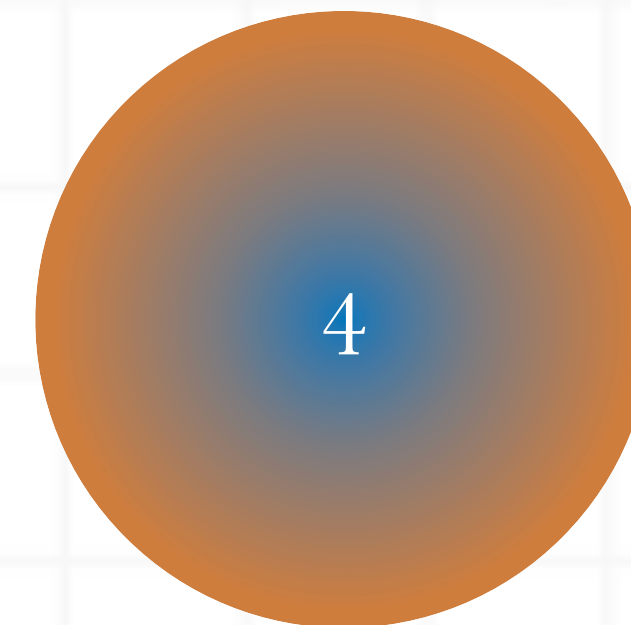
Physiological
aspects



Technical description
and specifications



Clinical
application



Product
aspects



Future
perspectives

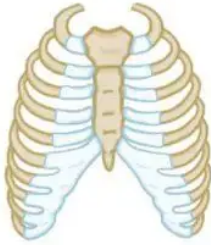
Joints structure and function

1. physiological aspects

206 bones

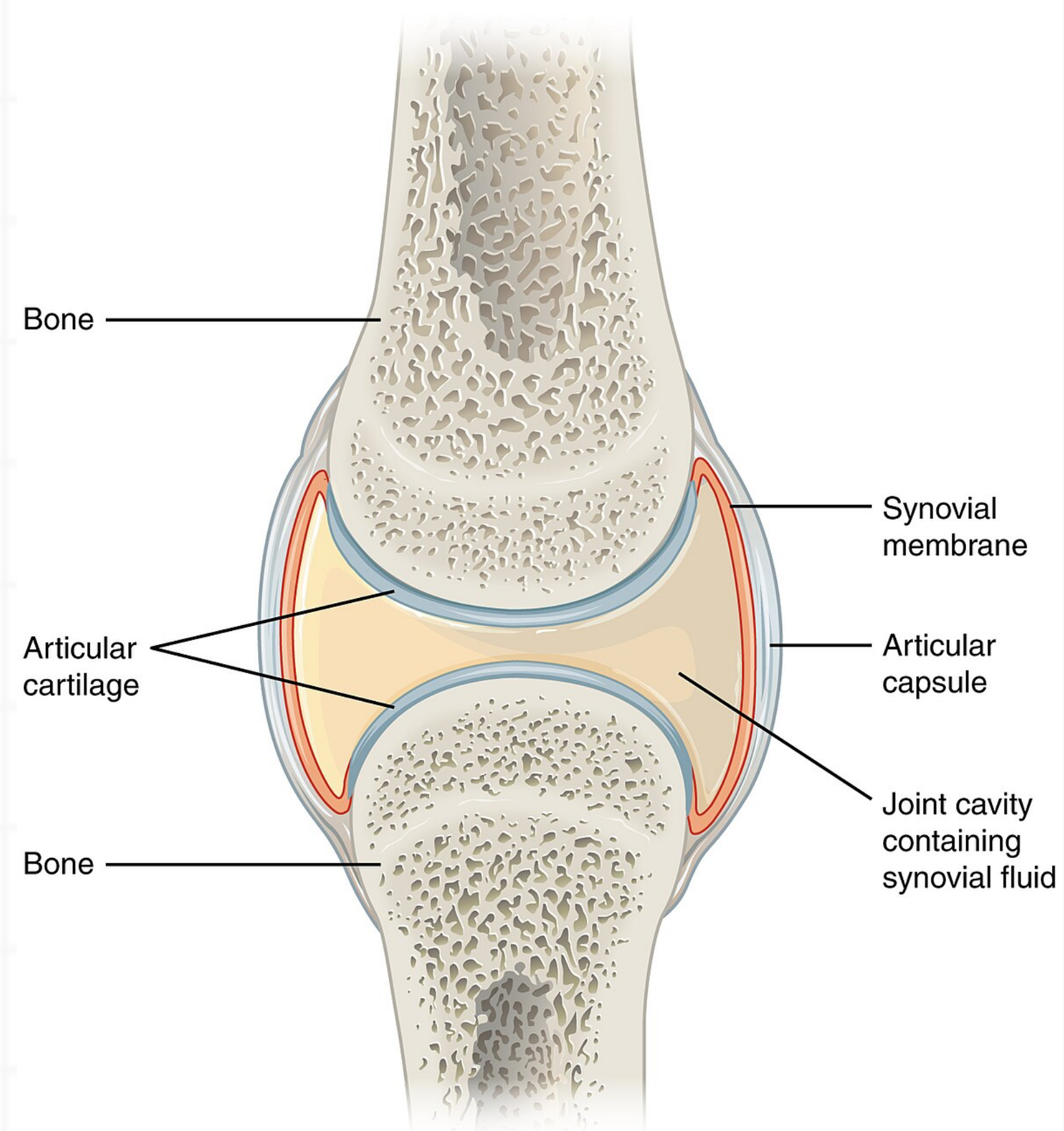
connected by 360 joints:



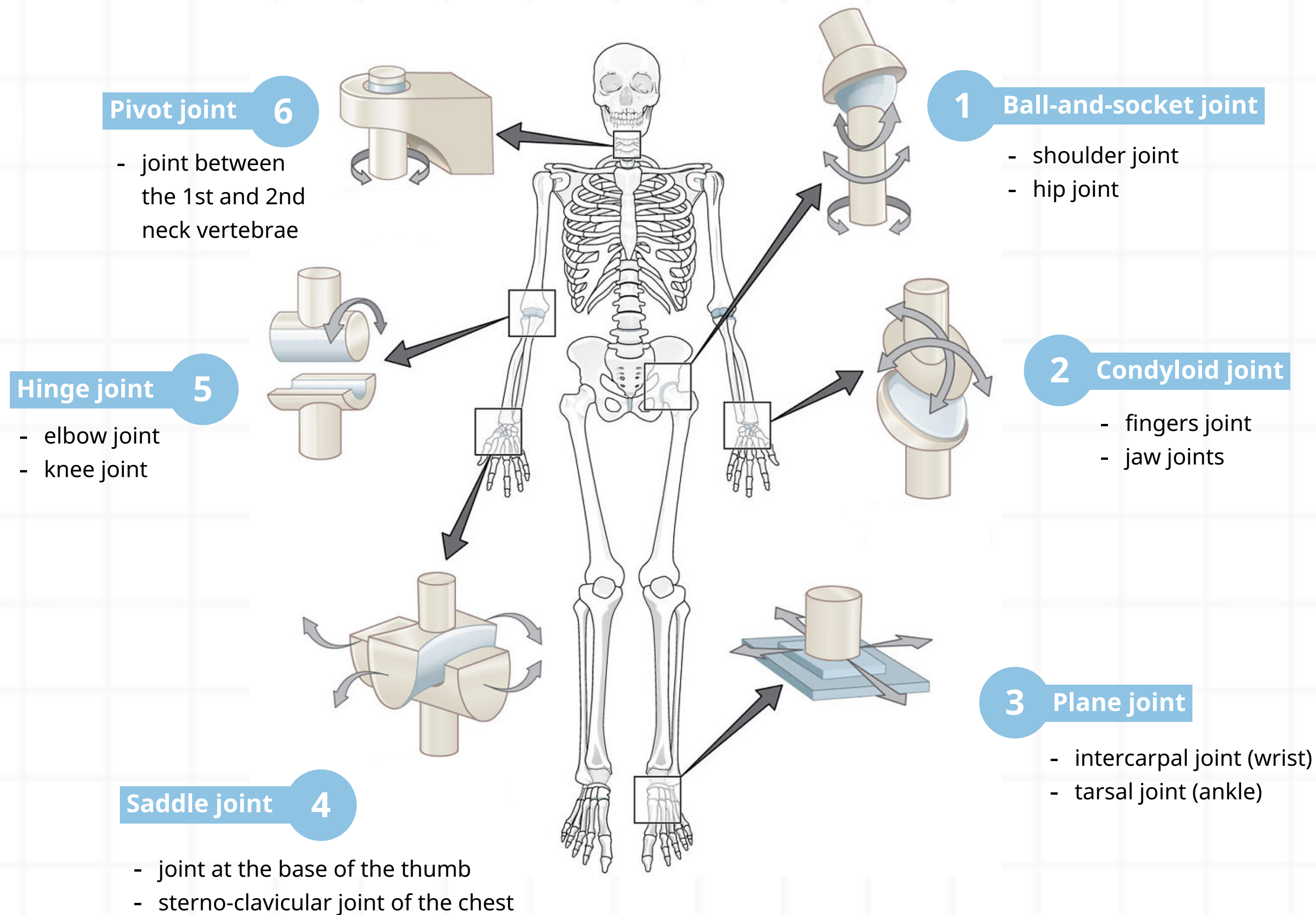
joint type	characteristics	examples
 FIBROUS JOINTS SYNARTHROSIS	- connected by fibrous connective tissue - rigid and relatively immovable	- skull sutures - joint that anchors a tooth to its socket in the jaw
 CARTILAGINOUS JOINTS AMPHIARTHROSIS	- connected by cartilage - limited motion in response to twisting / compression	- joints of the vertebral system - joints that attach the ribs to the vertebral column
 SYNOVIAL JOINTS DIARTHROSIS	- fluid-filled joint cavities - highly mobile	- knee joint - elbow joint

Synovial joints

1. physiological aspects



Key components structure



Types of movements allowed

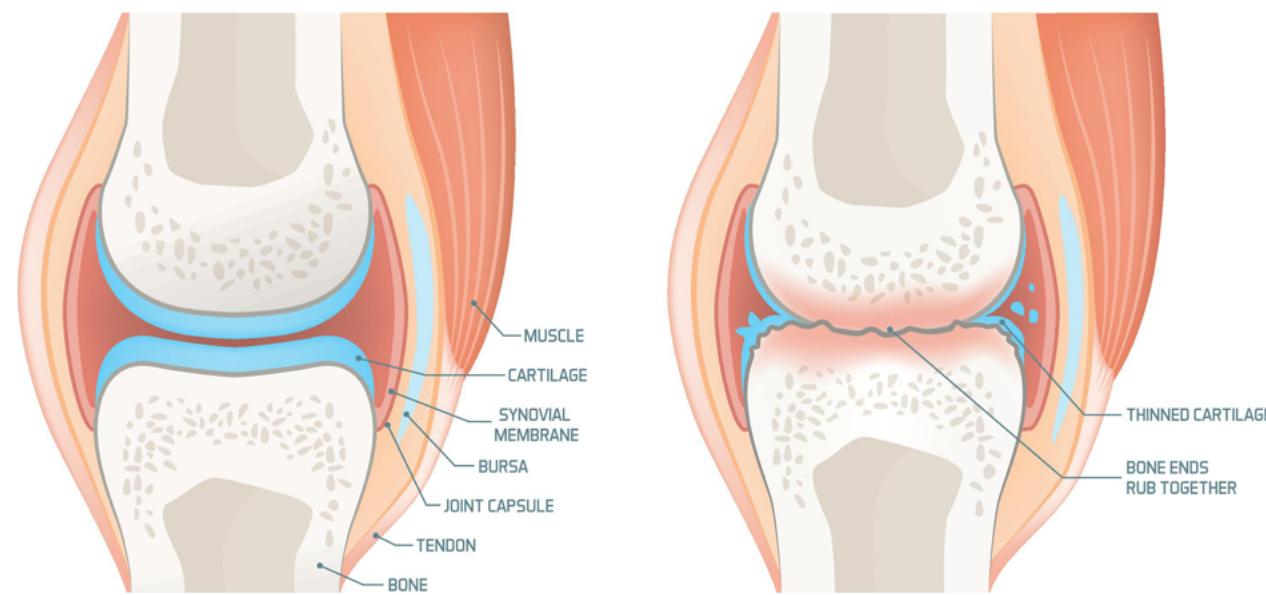
Joint issues

1. physiological aspects

Osteoarthritis (OA)

example of the knee

- degenerative joint disease
- caused by the wear and tear of the cartilage
- affects commonly weight-bearing joints



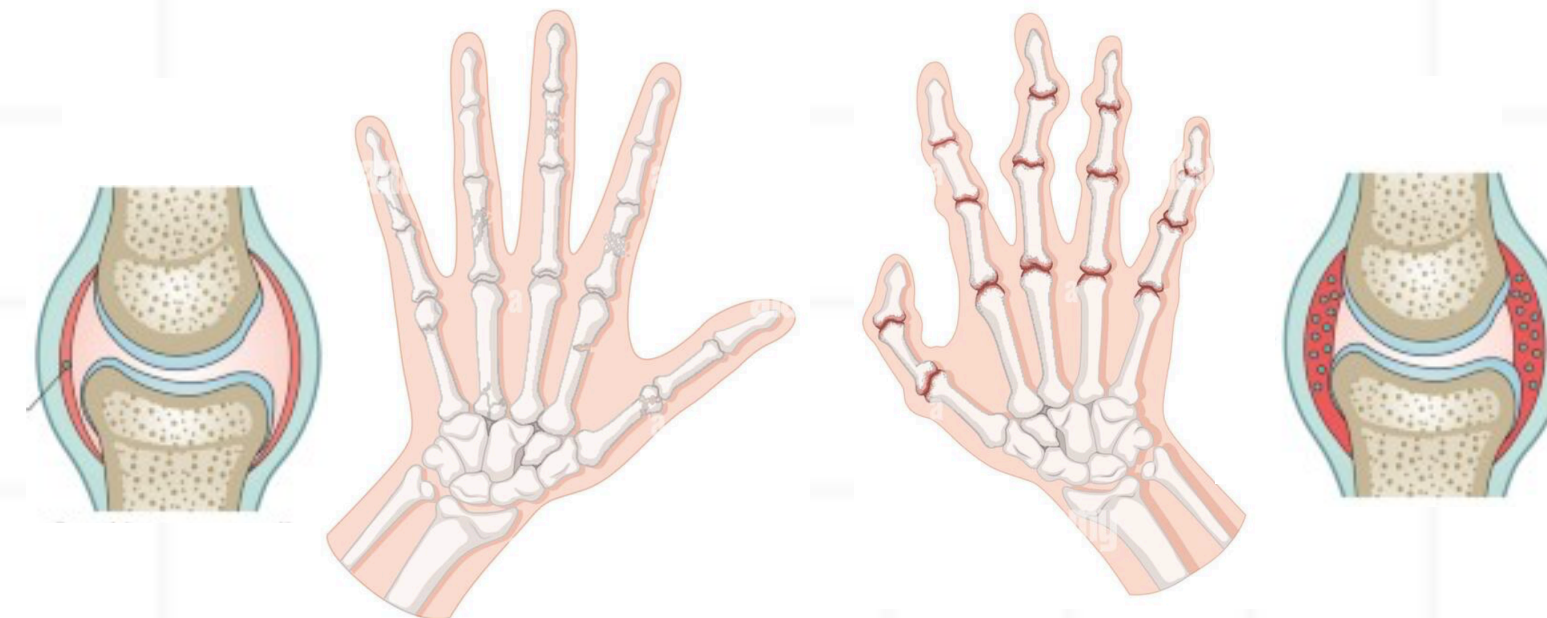
Healthy knee

Knee suffering from osteoarthritis

Rheumatoid arthritis (RA)

example of the fingers

- autoimmune inflammatory joint disease
- caused by the immune cell infiltration
- affects commonly small joints



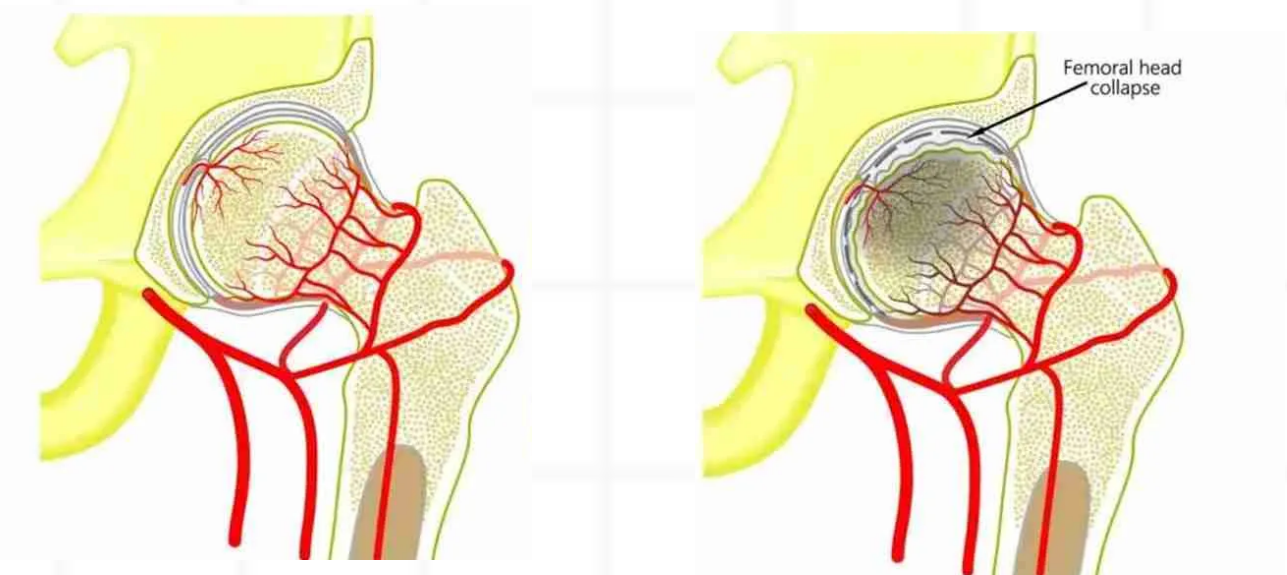
Healthy fingers

Finger suffering from rheumatoid arthritis

Avascular necrosis

example of the hip

- death of bone tissue
- caused by the loss of blood supply to the joint
- affects commonly hip, shoulder, knee, and ankle joints



Healthy hip

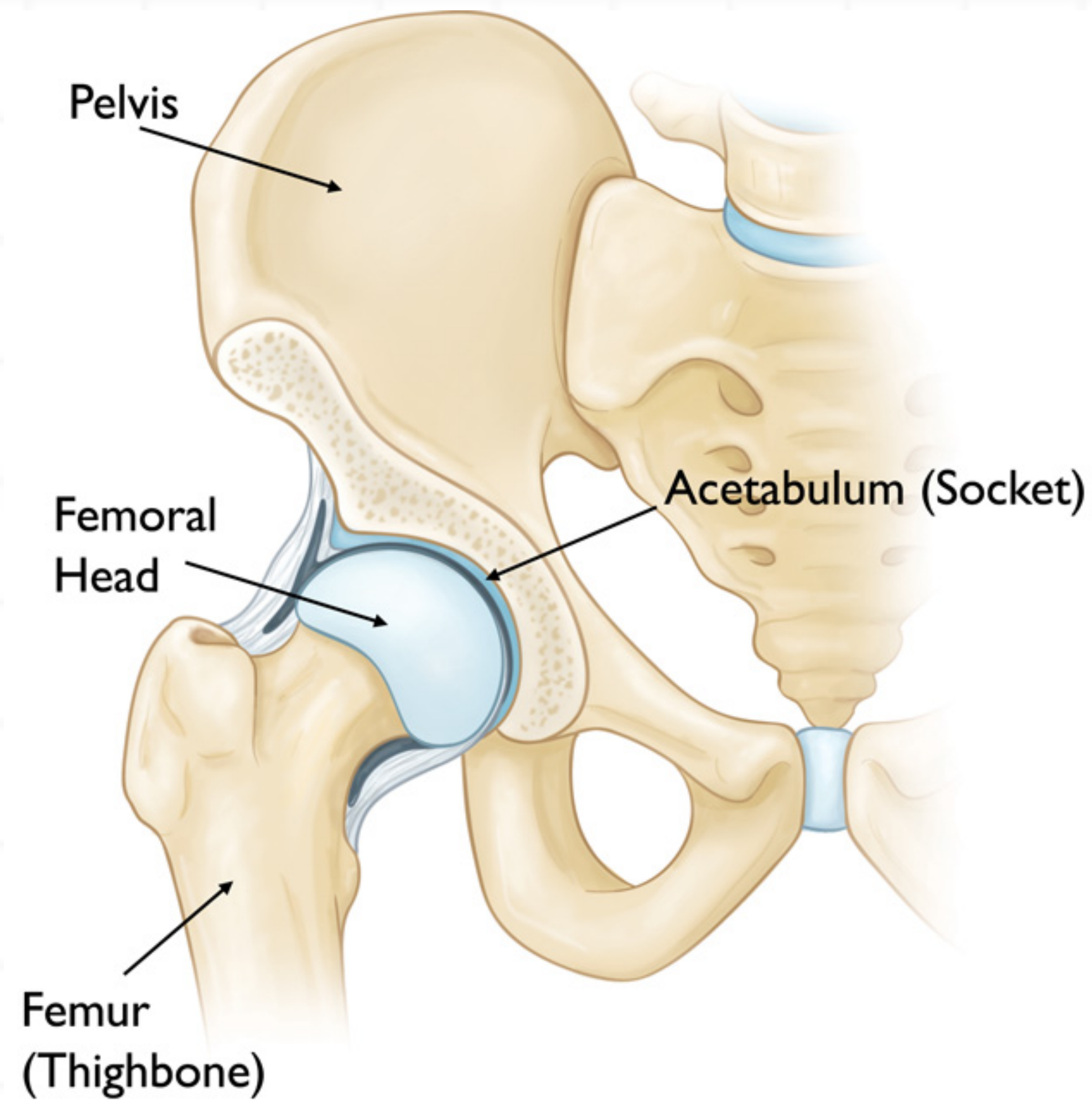
Hip suffering from avascular necrosis

Fractures / injuries

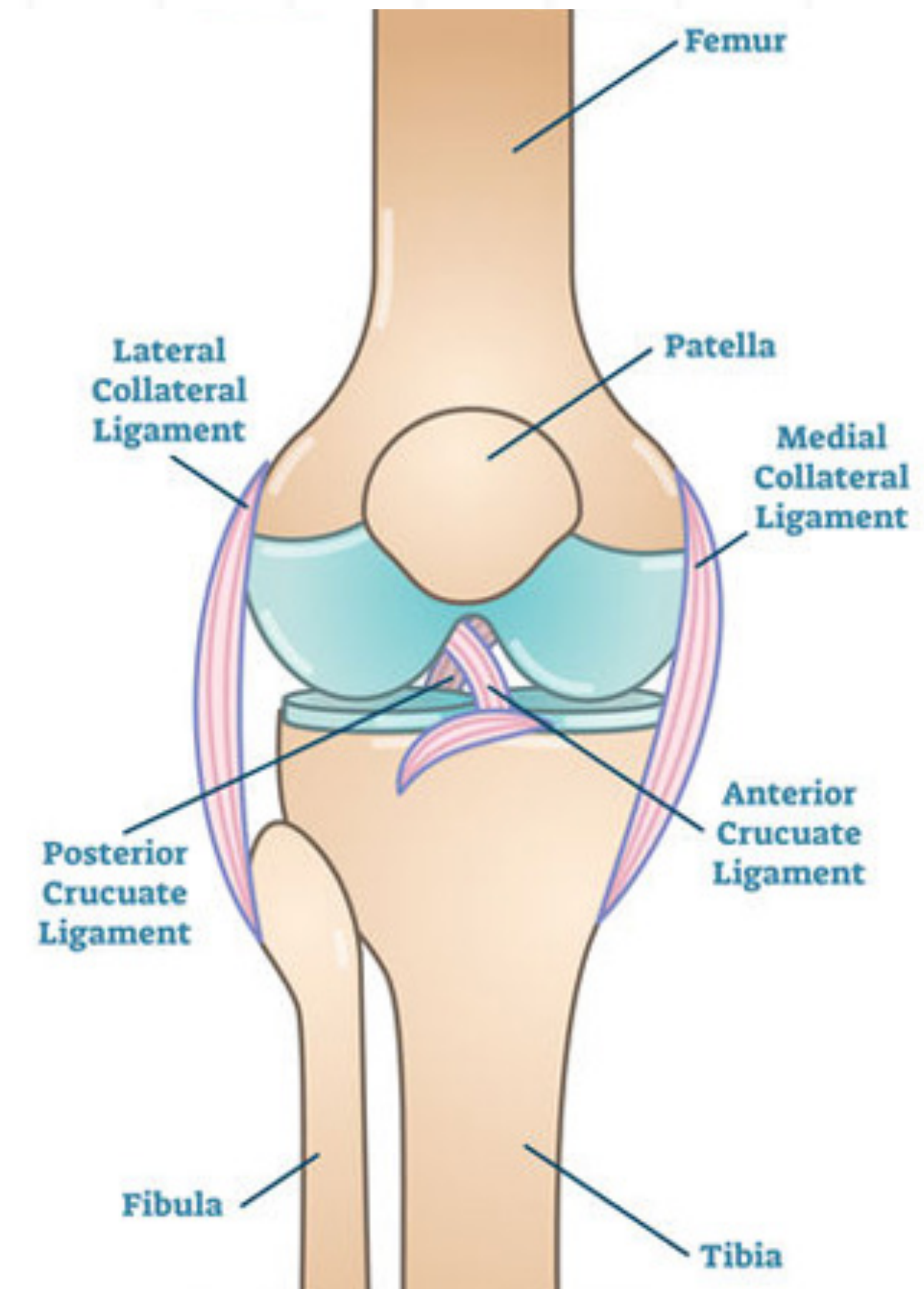
- physical damage
- caused by accidents

Hip and knee joints

1. physiological aspects



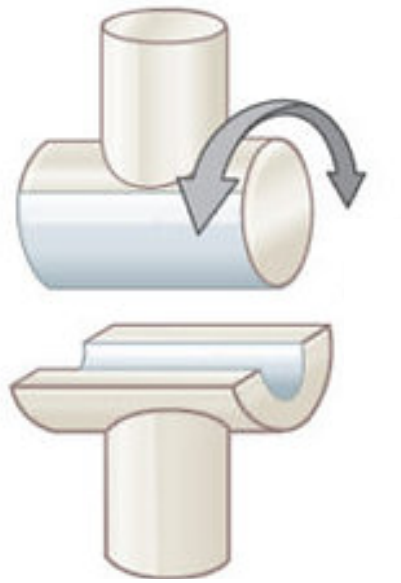
HIP JOINT



KNEE JOINT



Ball-and-socket joint



Hinge joint +

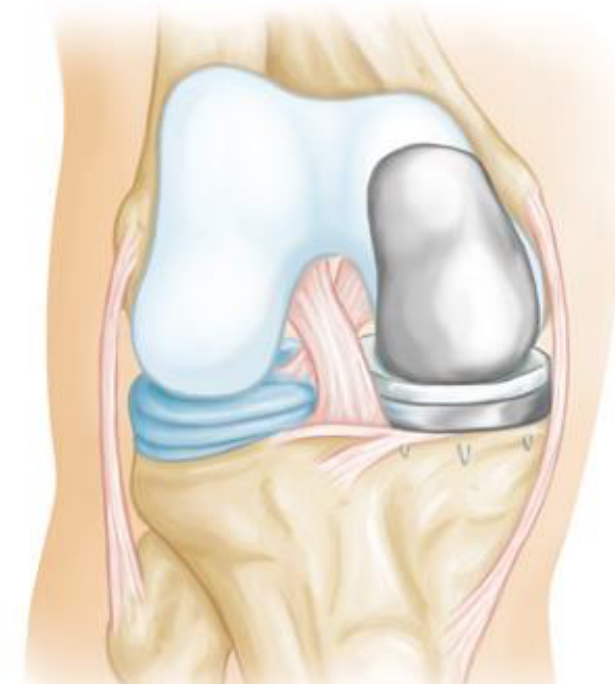
Types of replacement

2. technical description

PARTIAL JOINT REPLACEMENT (PJR)

- recommended for younger patient (< 65 yo) and early stage joint disease
- less invasive
- faster recovery time

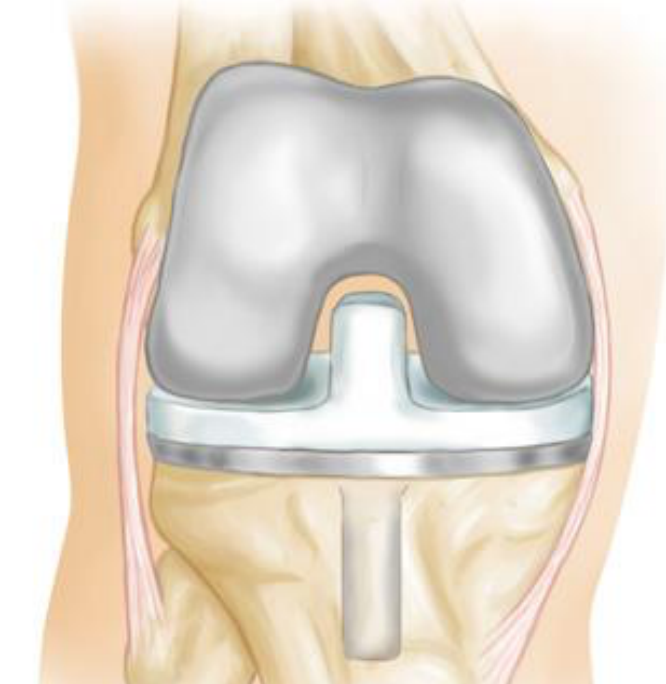
example of the knee



example of the hip

TOTAL JOINT REPLACEMENT (TJR)

- recommended for widespread damage
- more durable, but can require a revision surgery ($\pm 15-20$ years)
- more invasive
- longer recovery time



Surgical procedure

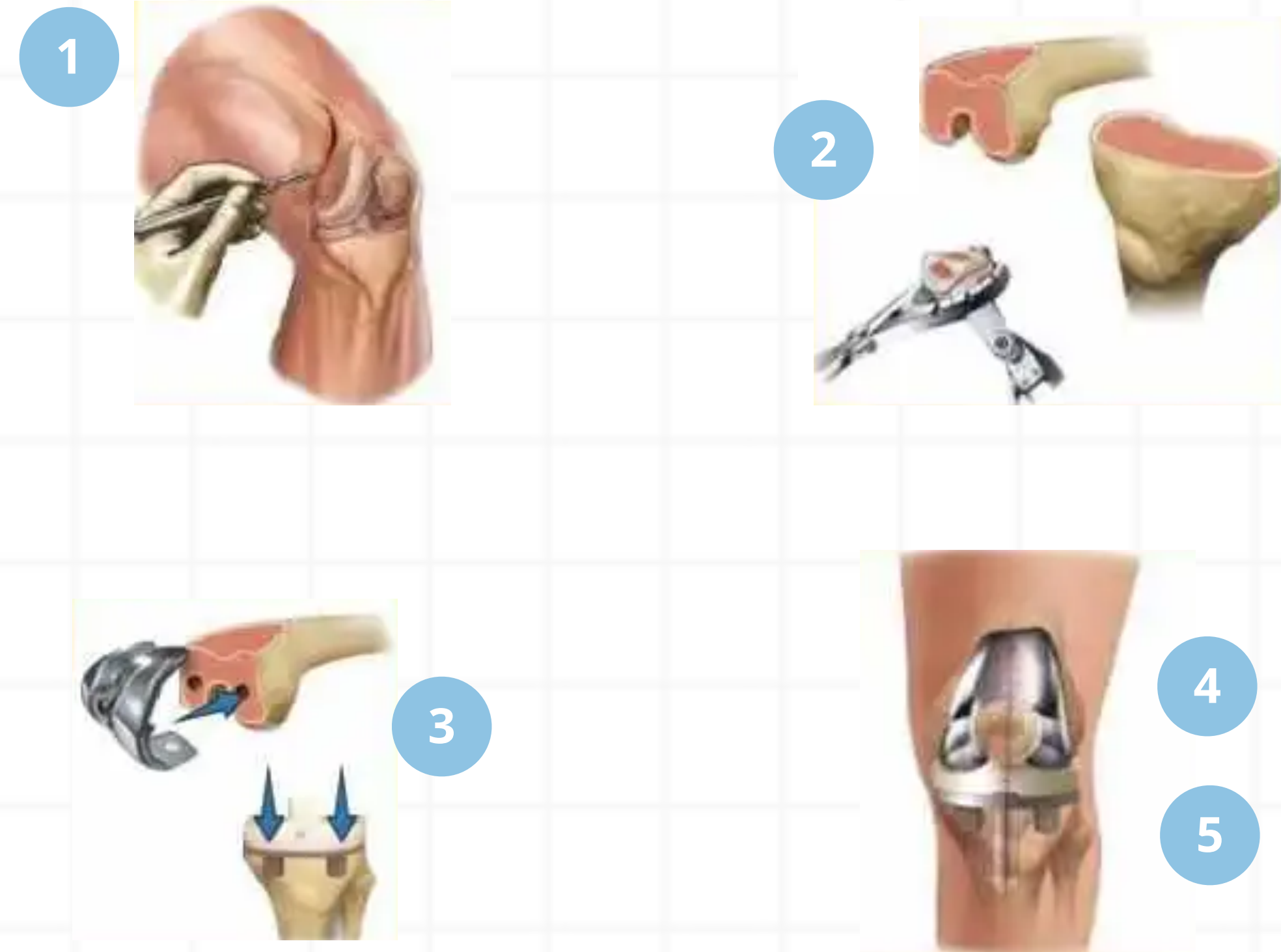
2. technical description

Steps for synovial joint replacement:

1. incision to expose and access the joint
2. removal of damaged parts
3. fixation of the artificial components
4. range of motion and alignment testing
5. wound closure

Recovery time

- between 1 and 4 days at the hospital
- need physical therapy
- avoid bending, twisting and squatting for 6-12 months



Example of a total knee replacement surgery

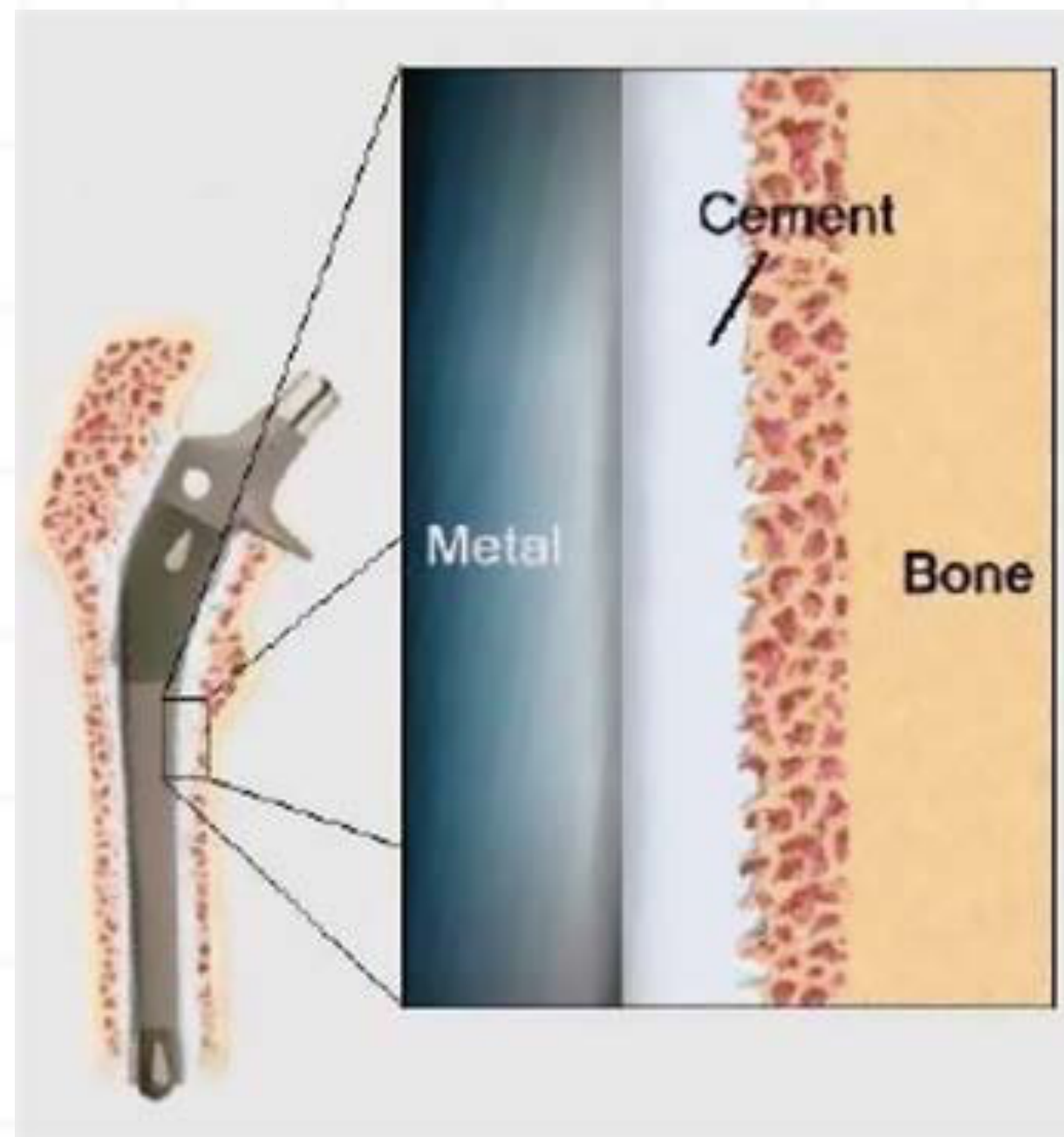
Fixation

2. technical description

CEMENTED FIXATION

use a bone cement

eg. PMMA (polymethyl methacrylate)



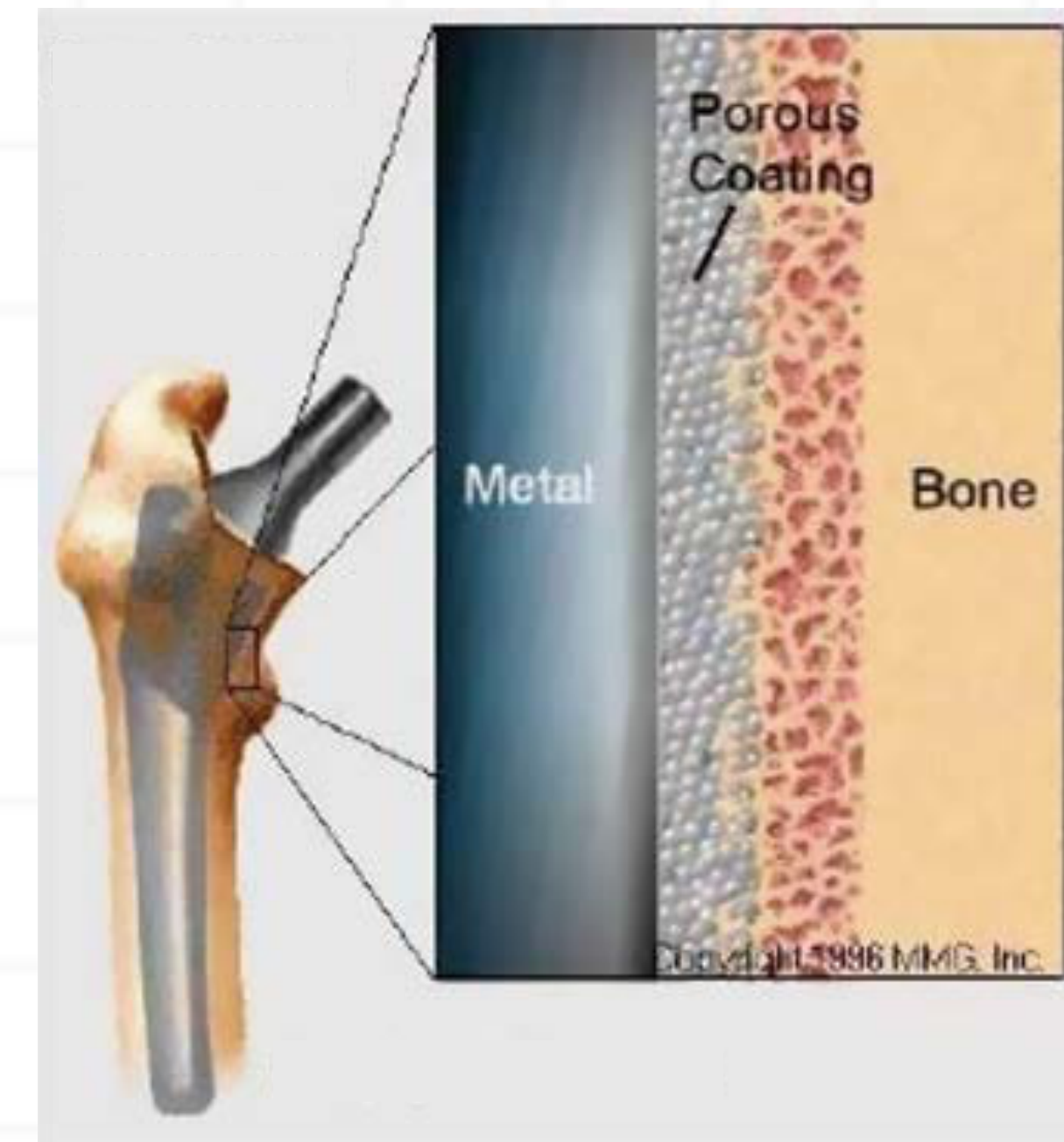
→ adapted for older patient
because of an immediate fixation

CEMENTLESS FIXATION

use of a porous implant material (+ coating biomaterial)

eg. titanium alloy + hydroxyapatite

eg. Trabecular Metal® Technology from Zimmer Biomet

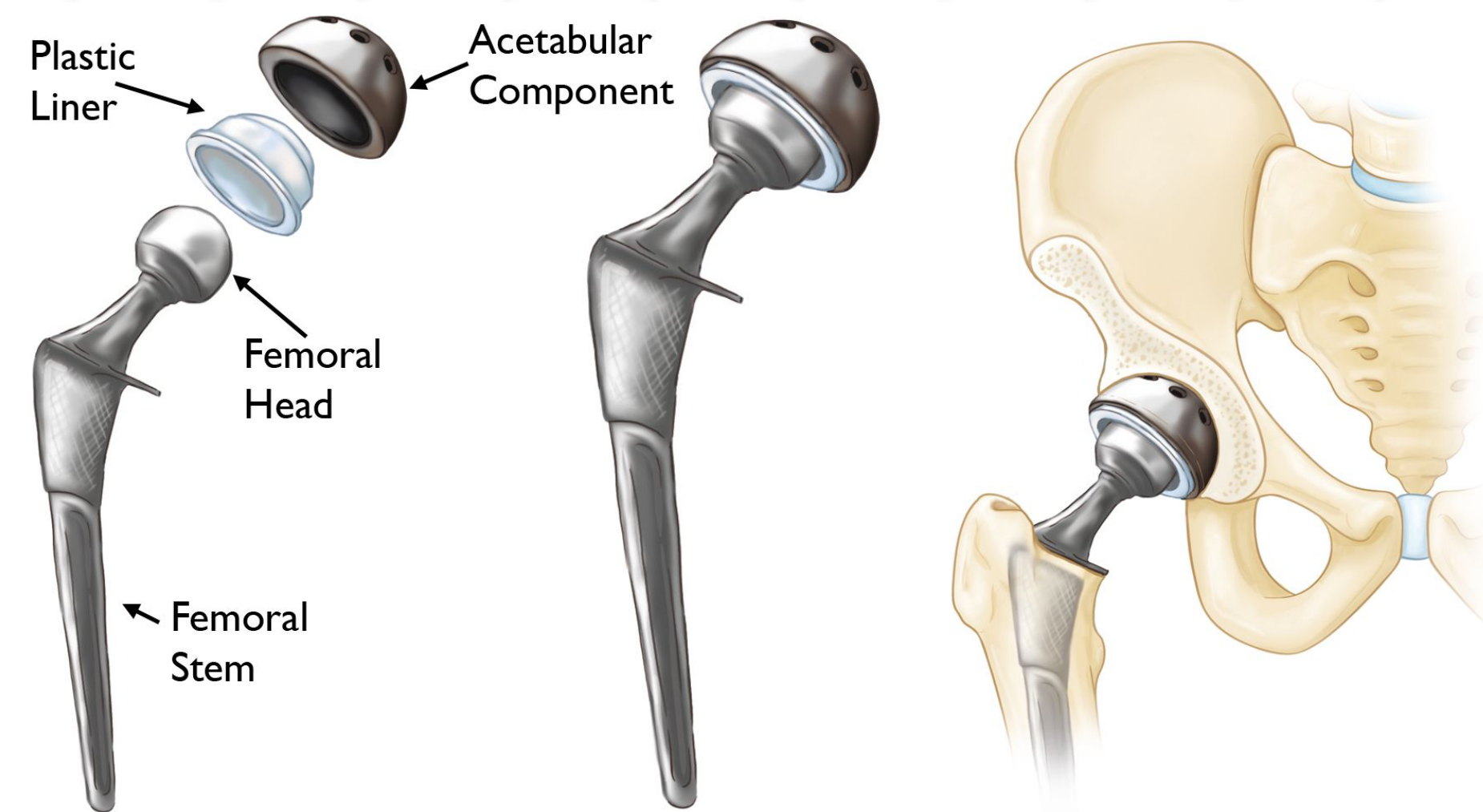


→ adapted for younger patient
because of a better osseointegration

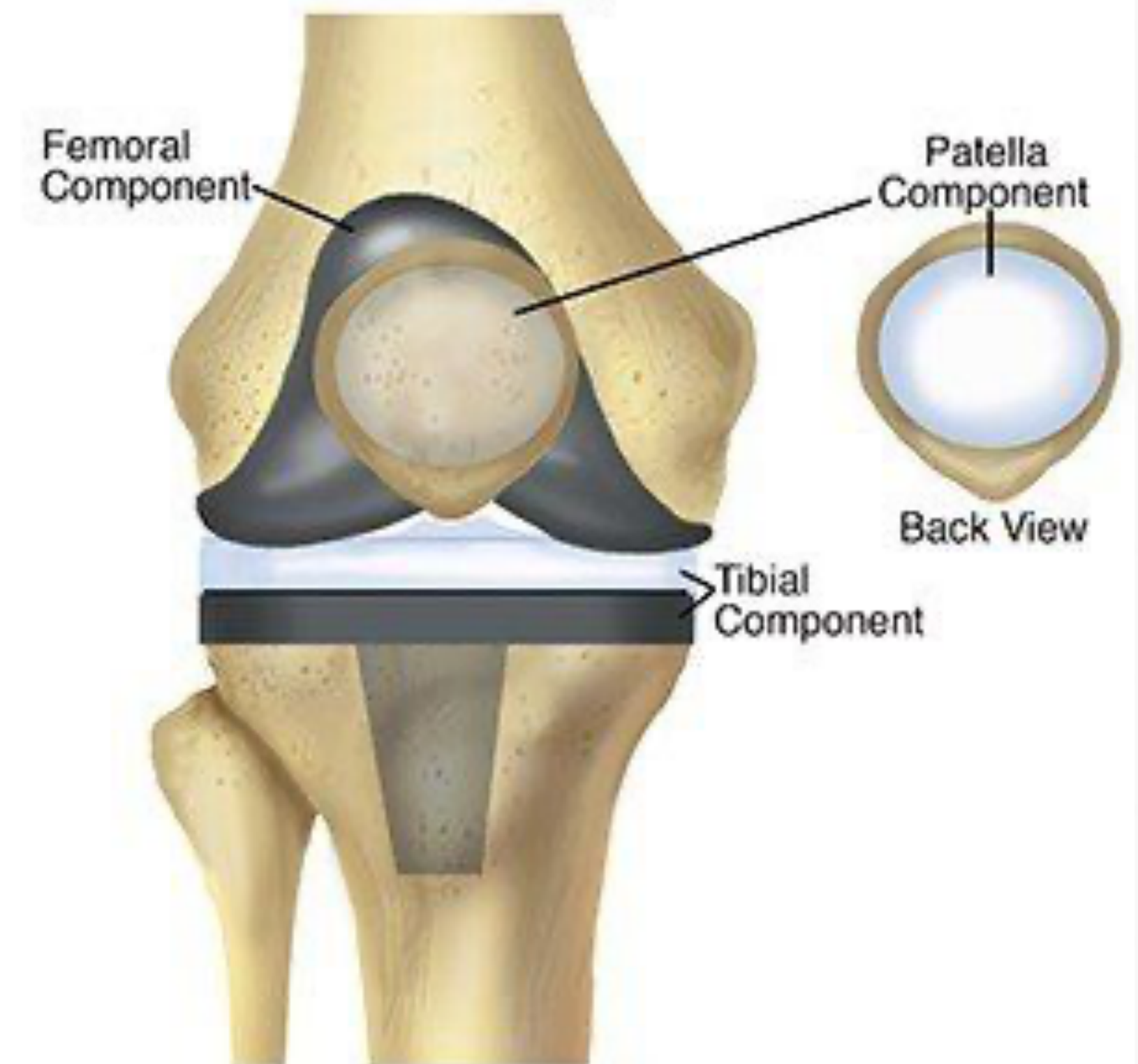
Specifications

2. technical description

Total hip replacement (THR)



Total knee replacement (TKR)



Materials

2. technical specifications

Metals

→ used in structural parts

- titanium
- cobalt chromium alloys
- stainless steel (less used now)

FEMORAL COMPONENT
Metal



TIBIAL BASEPLATE
Metal



knee replacement

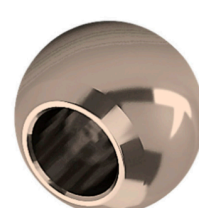
FEMORAL STEM

Metal - Cementless or cemented



HEAD

Co-Cr Head



CUP

Metal or polyethylene
Cementless or cemented



hip replacement

Ceramics

→ used for articulating surfaces

- aluminum oxide
- zirconium dioxide

HEAD

Ceramic or metal



LINER

Ceramic or polyethylene



hip replacement

Plastic

→ used to create a smooth contact

- ultra-high-molecular-weight polyethylene (UHMWPE)

PLASTIC TIBIAL INSERT

Polyethylene



knee replacement

LINER

Ceramic or polyethylene



hip replacement

Combinations

→ used to provide the best balance

eg. ceramic femoral head with a polyethylene acetabular liner



Metal on plastic



Ceramic on plastic

hip replacement

Issues

3. clinical applications

Risks related to the surgical intervention

- infection at the surgical site
- blood clots leading to deep vein thrombosis or even pulmonary embolism)

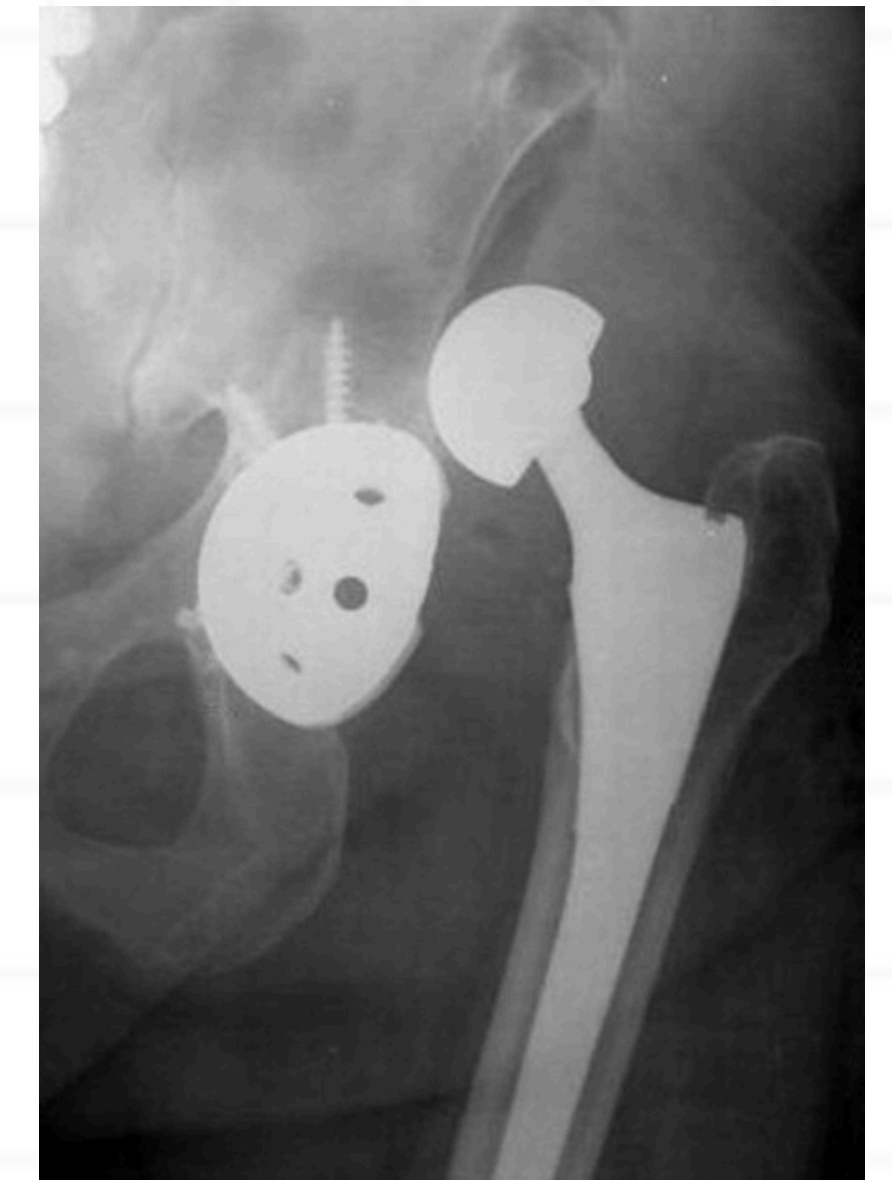
Risks related to the joint replacement

- loosening : gaps between the implant and the bone
- dislocation : disrupting the alignment of the joint components
- difference in leg lengths
- wear debris released from the implant : can lead to osteolysis

→ may involve a **revision surgery**



TKR loosening



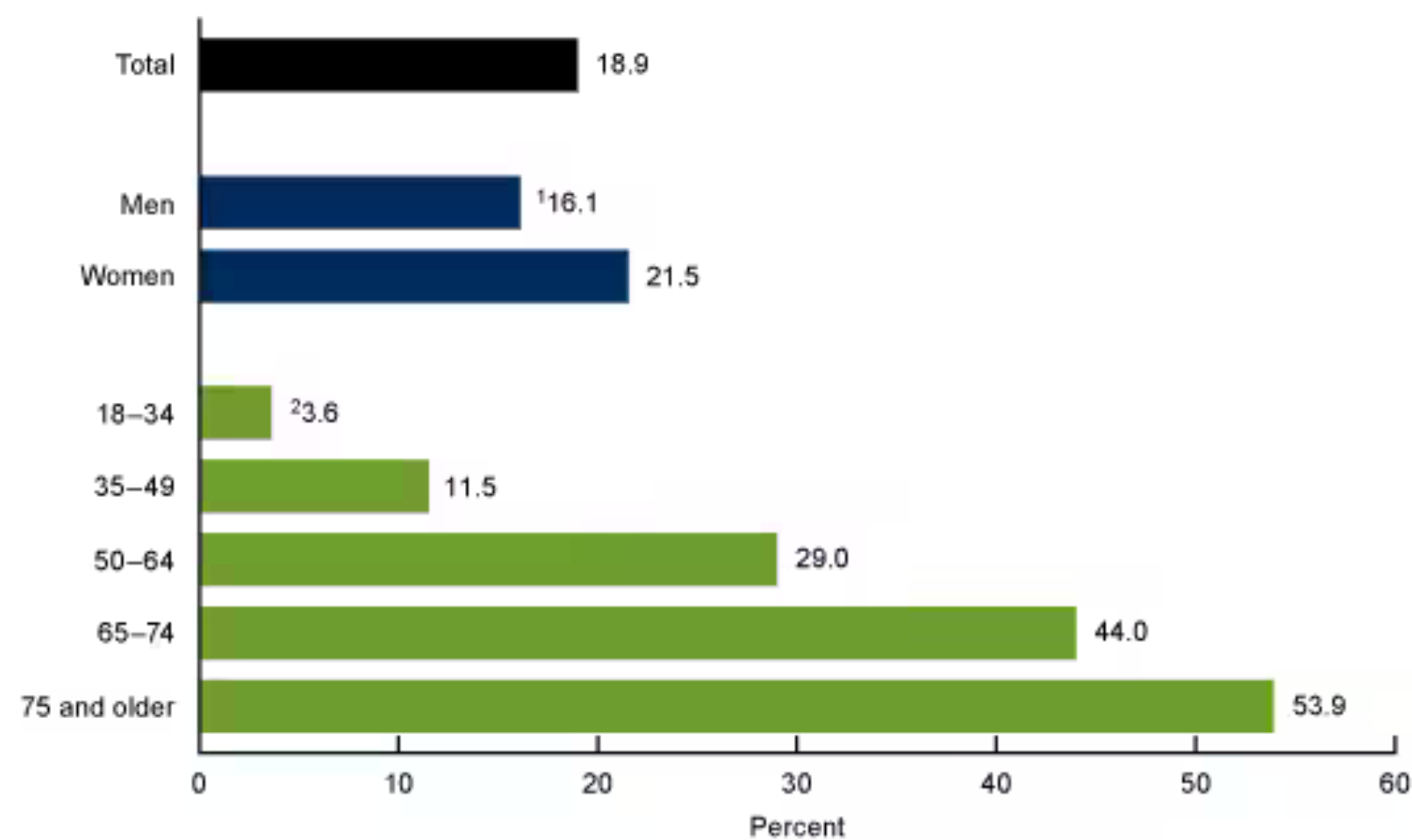
THR dislocation



Wear debris cycle

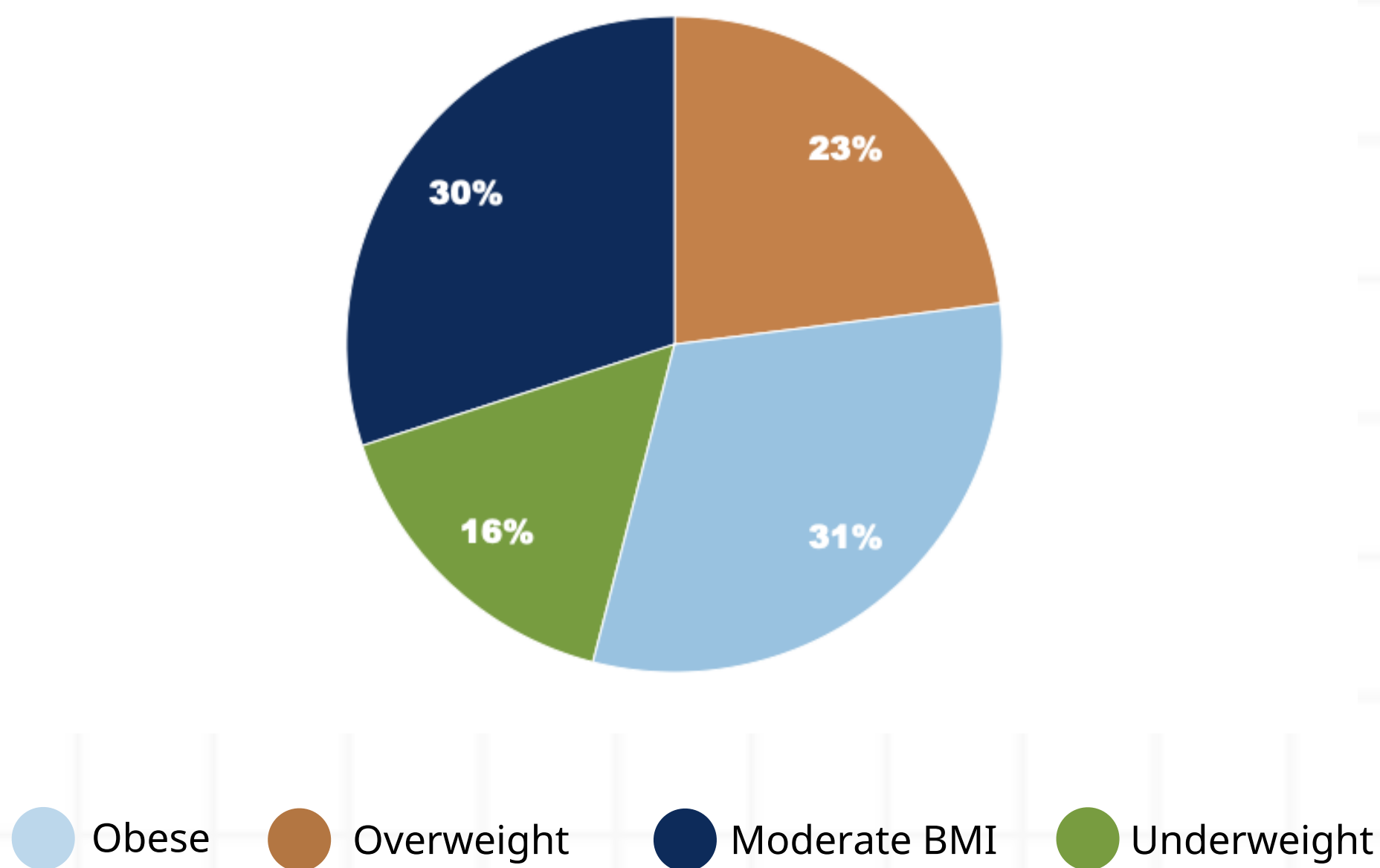
Risks factors

3. clinical applications



Age-adjusted percentage of adults age 18 and older with arthritis, by sex and age group: United States, 2022

National Center for Health Statistics, Data Brief, N°497, February 2024

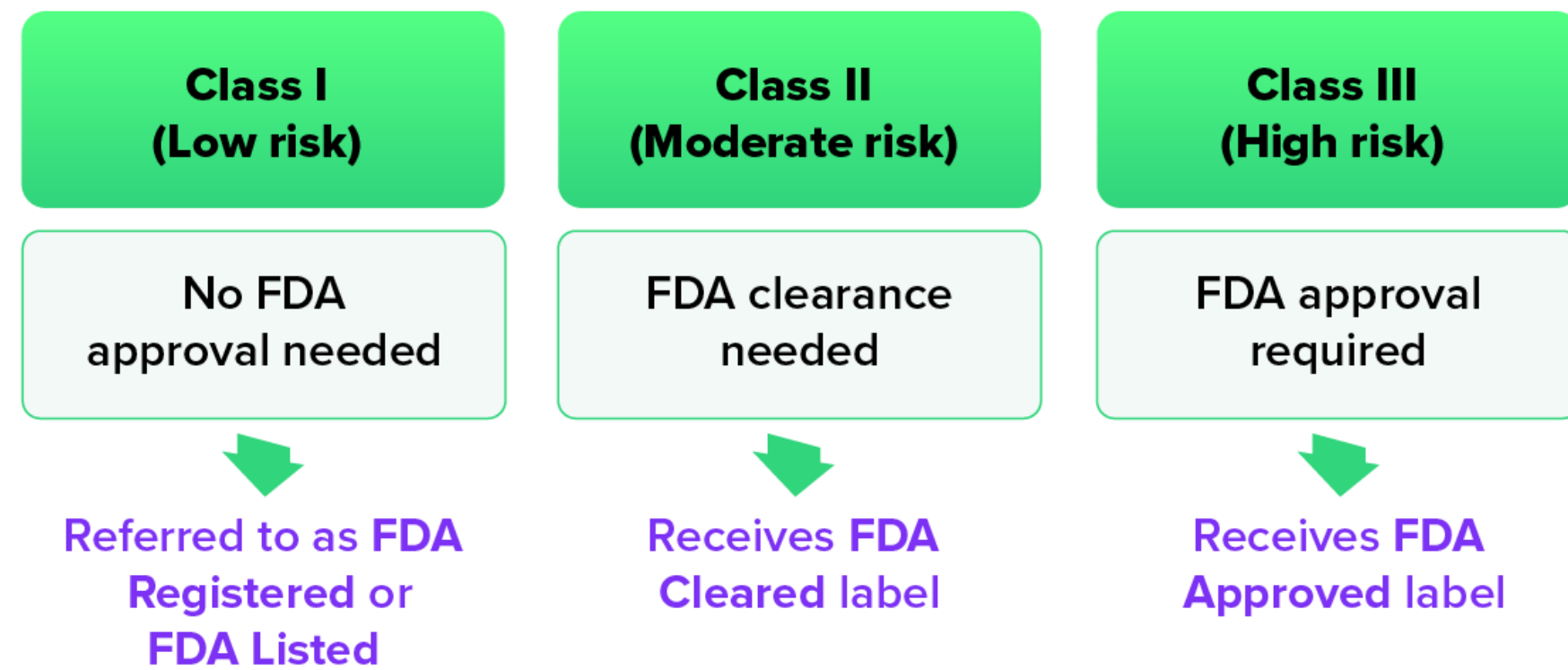
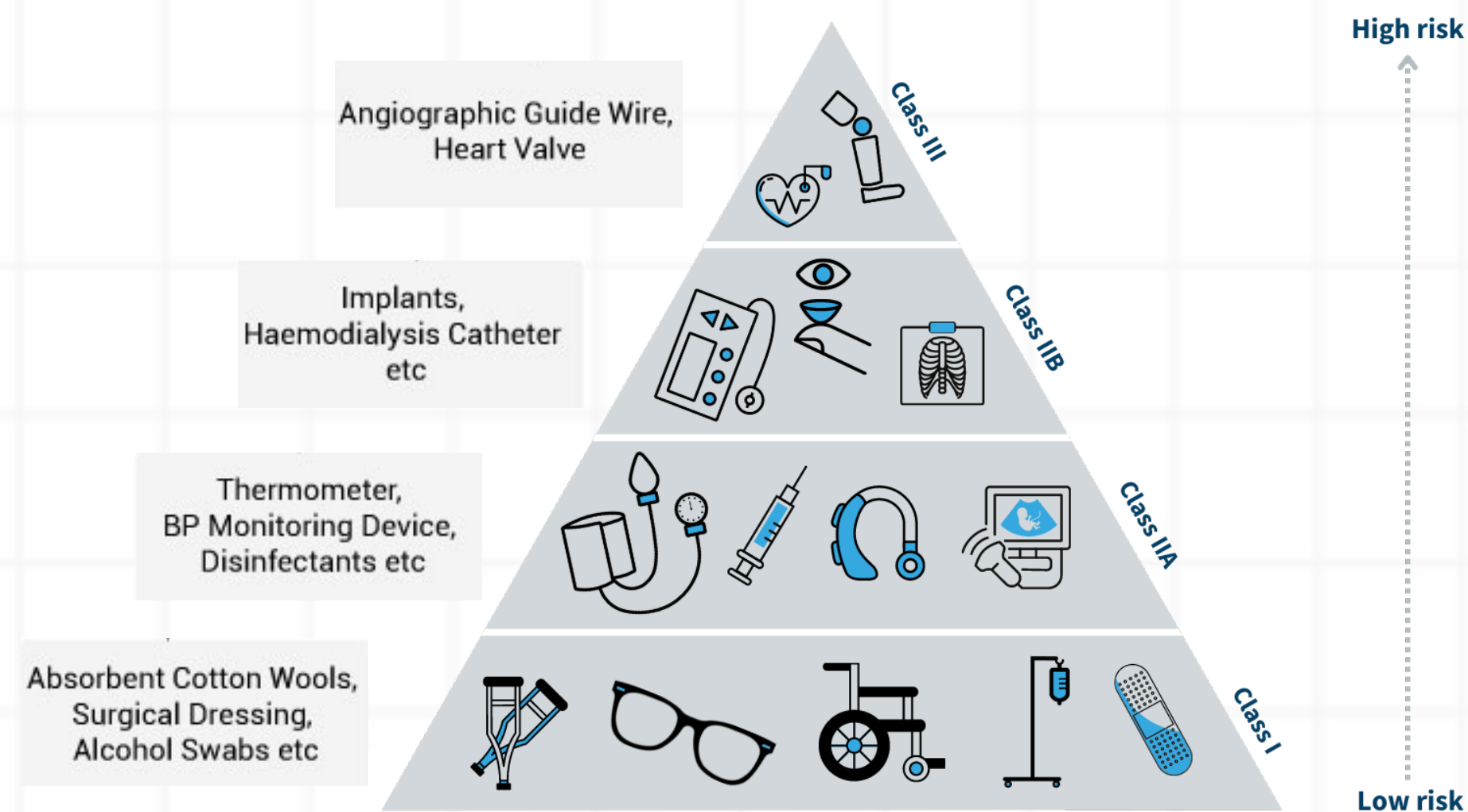


Pourcentage of people with osteoarthritis according to their BMI (Body Mass Index)

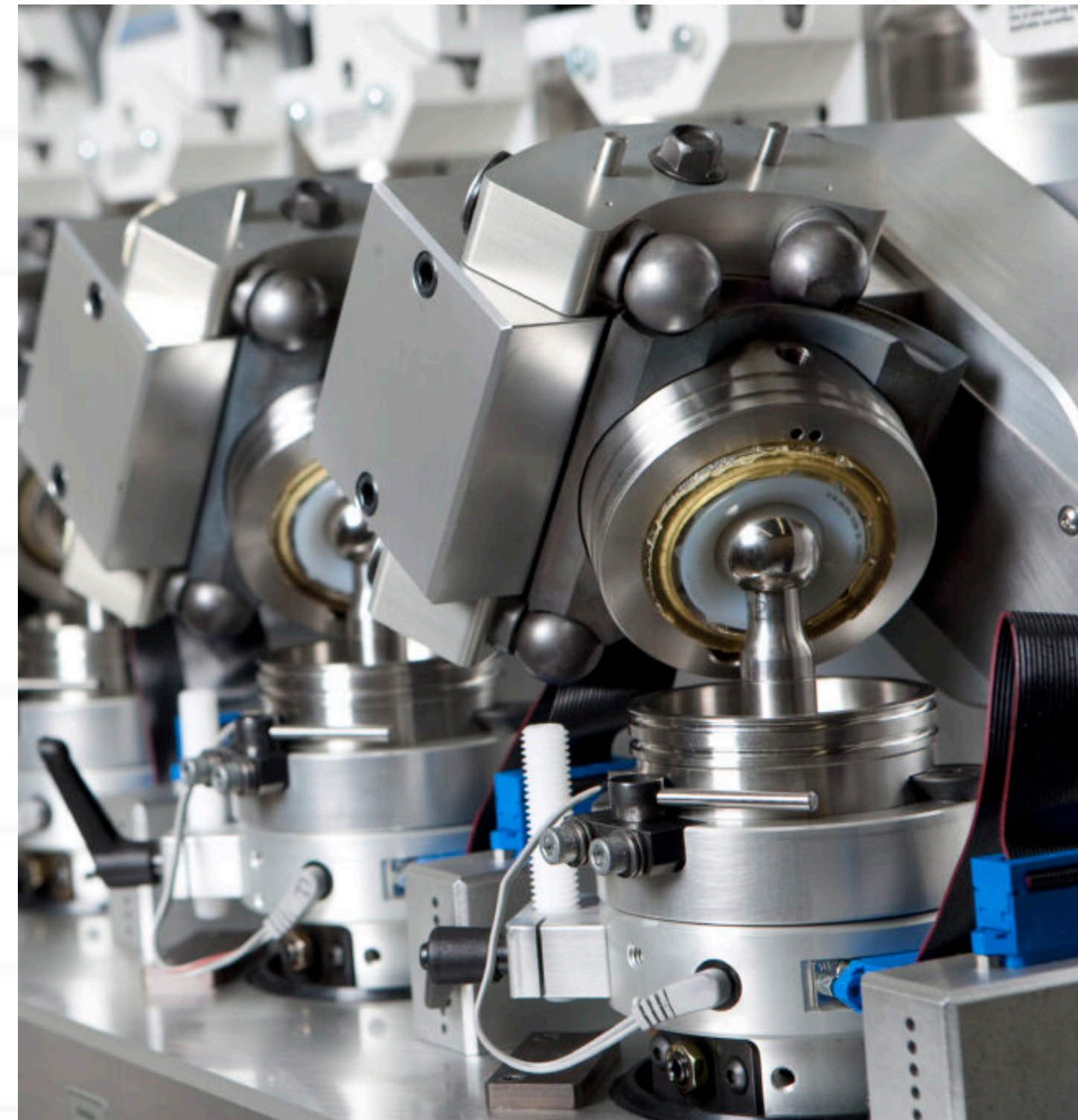
Centers for Disease Control and Prevention (CDC), 2020

Clinical trials

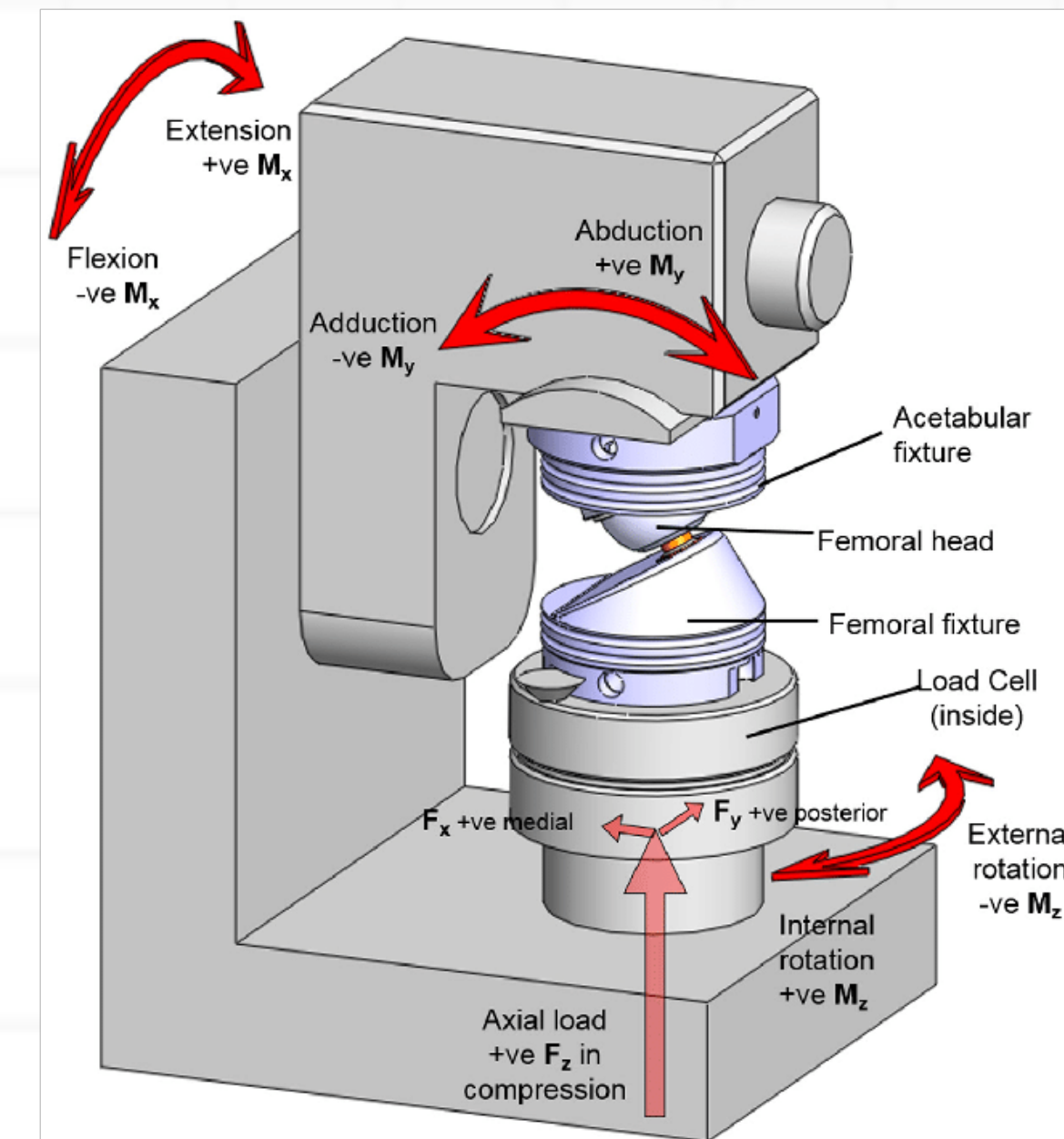
3. clinical applications



Steps required for medical devices according to their class



example of the AMTI's ADL (Activities of Daily Living) 12-Station Hip Simulator



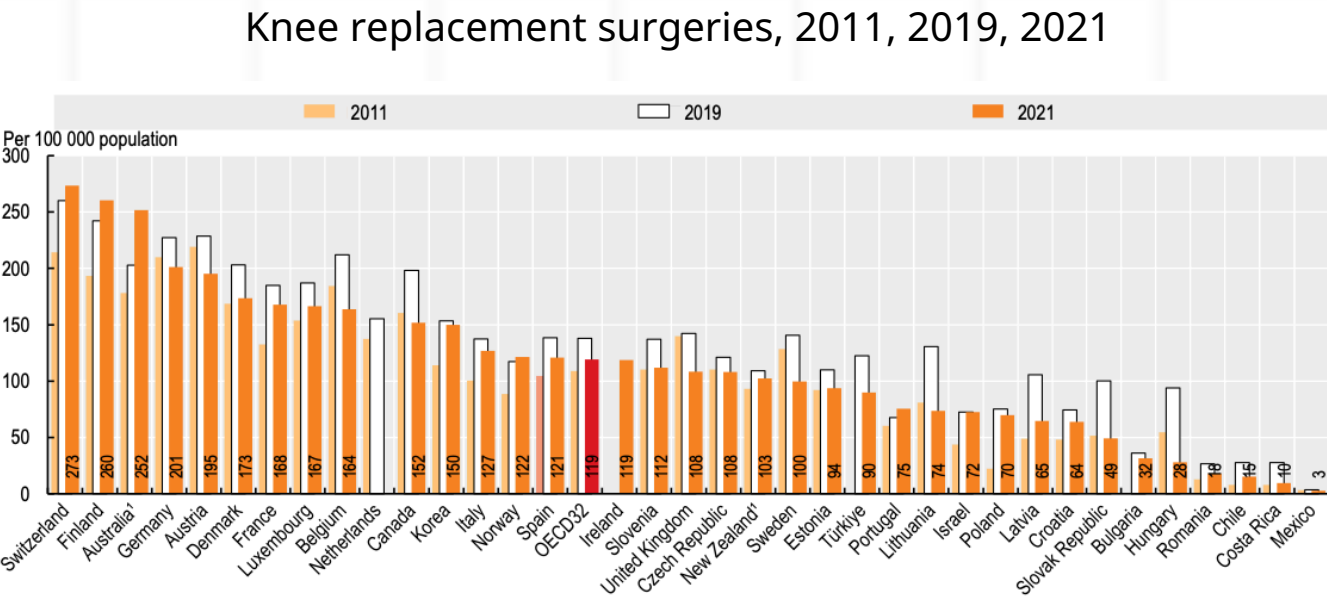
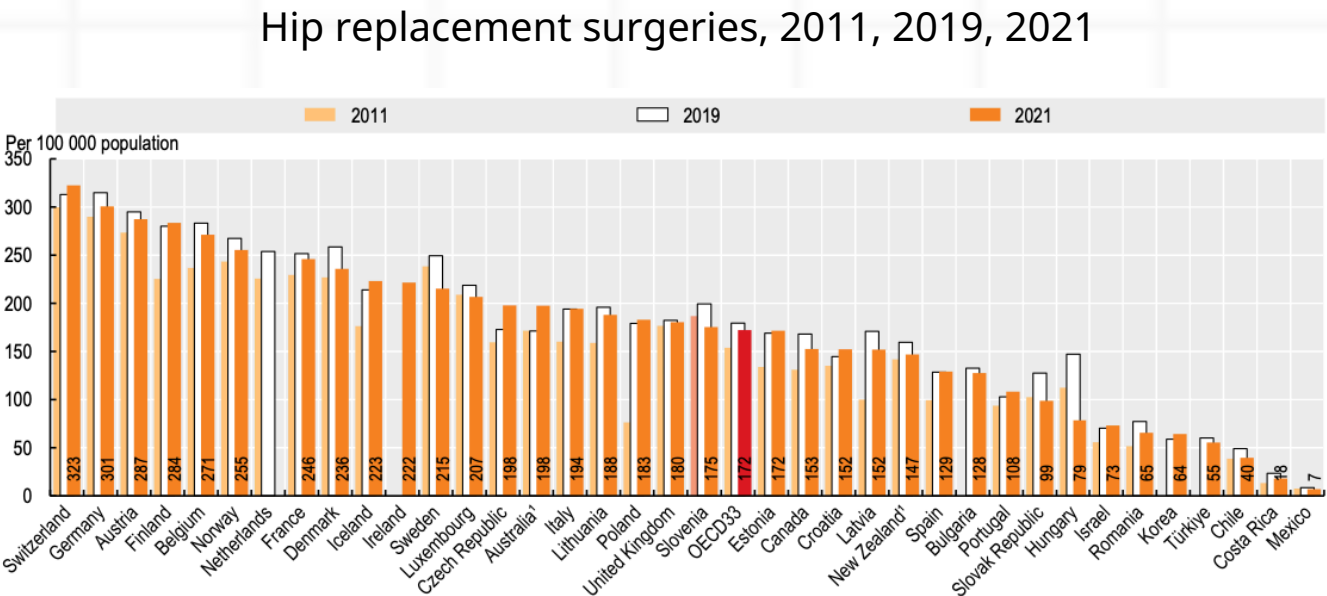
ISO 14242-1:2014

Implants for surgery — Wear of total hip-joint prostheses
“Loading and displacement parameters for wear-testing machines and corresponding environmental conditions for test”

Numbers

4. product aspects

Numbers of interventions

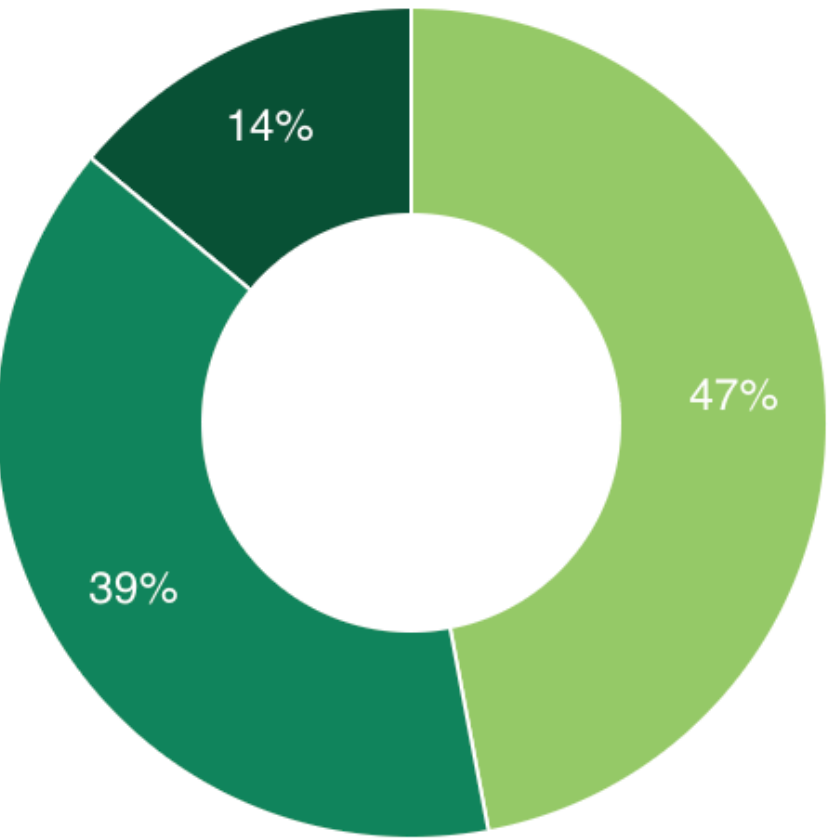


OECD Health at a Glance 2023,
'Hip and knee replacement' [p. 118-119]

Market value of
\$21,4 billions
(19 billion CHF)

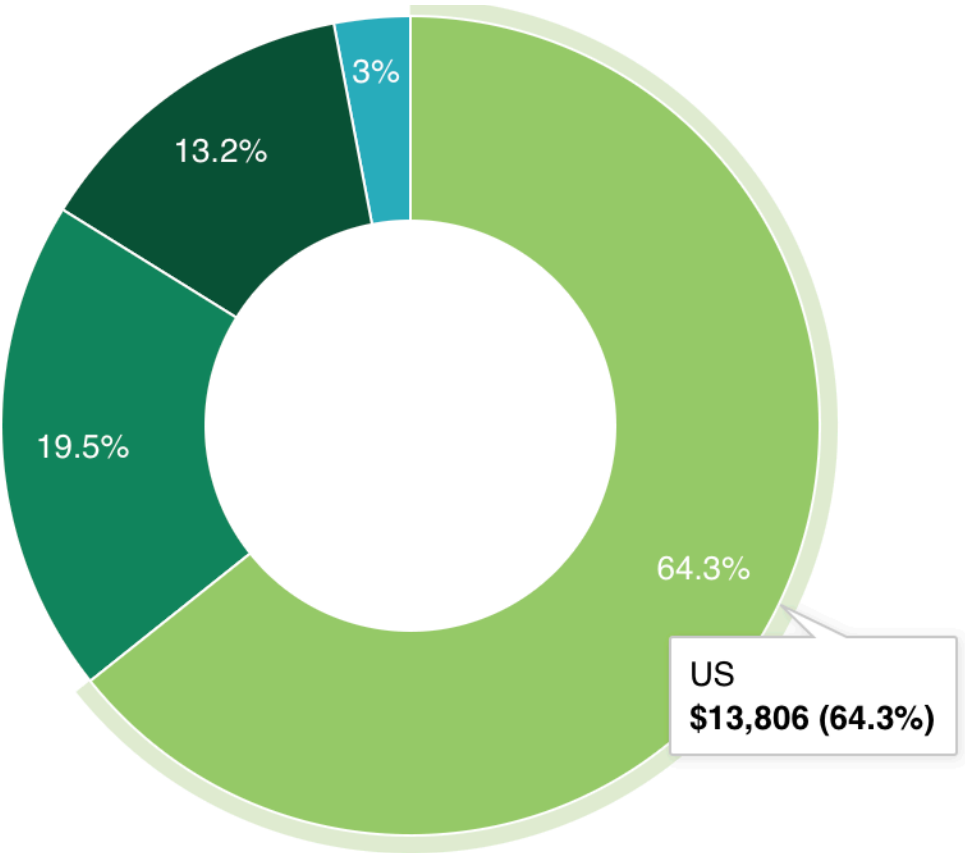
by type

- Knees
- Hips
- Extremities



by region

- US
- EMEA
- APAC
- ROW



"Overview of the joint replacement market"
in The Orthopedic Industry Annual Report®, September 2024

Costs

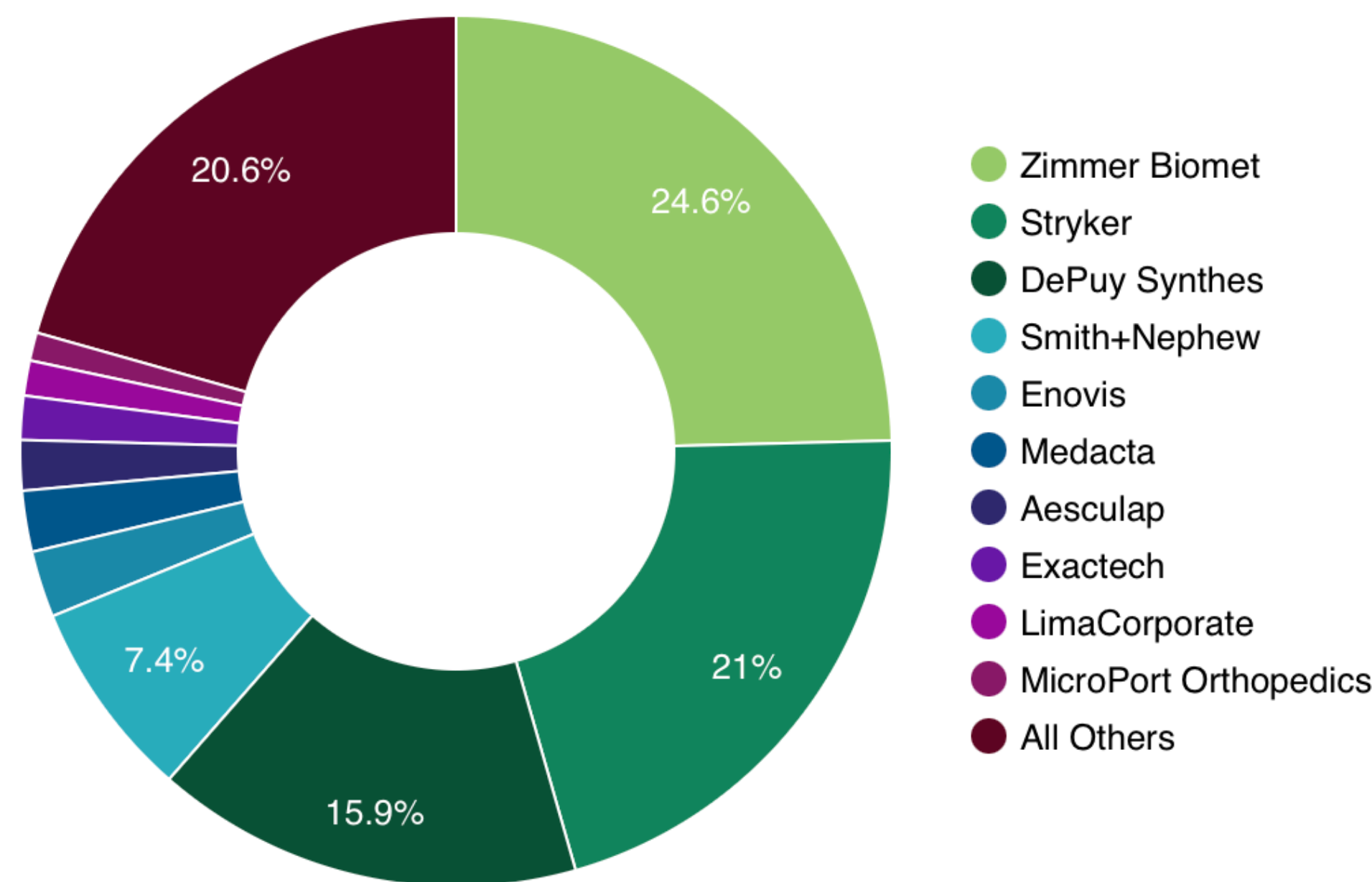
(Example of the US)

For a total hip replacement:
implant = ± \$3,000 to \$10,000
total cost = \$30,000 to \$112,000

AAHKS Patient and Public Relations Committee,
Report, 'Total Joint Replacement: A Breakdown of Costs'

Key players

4. product aspects



Joint replacement market share by company
“Overview of the joint replacement market”
in The Orthopedic Industry Annual Report®, September 2024



Patient specific instrumentation (PSI)

*Computed tomography
** Magnetic Resonance Imaging

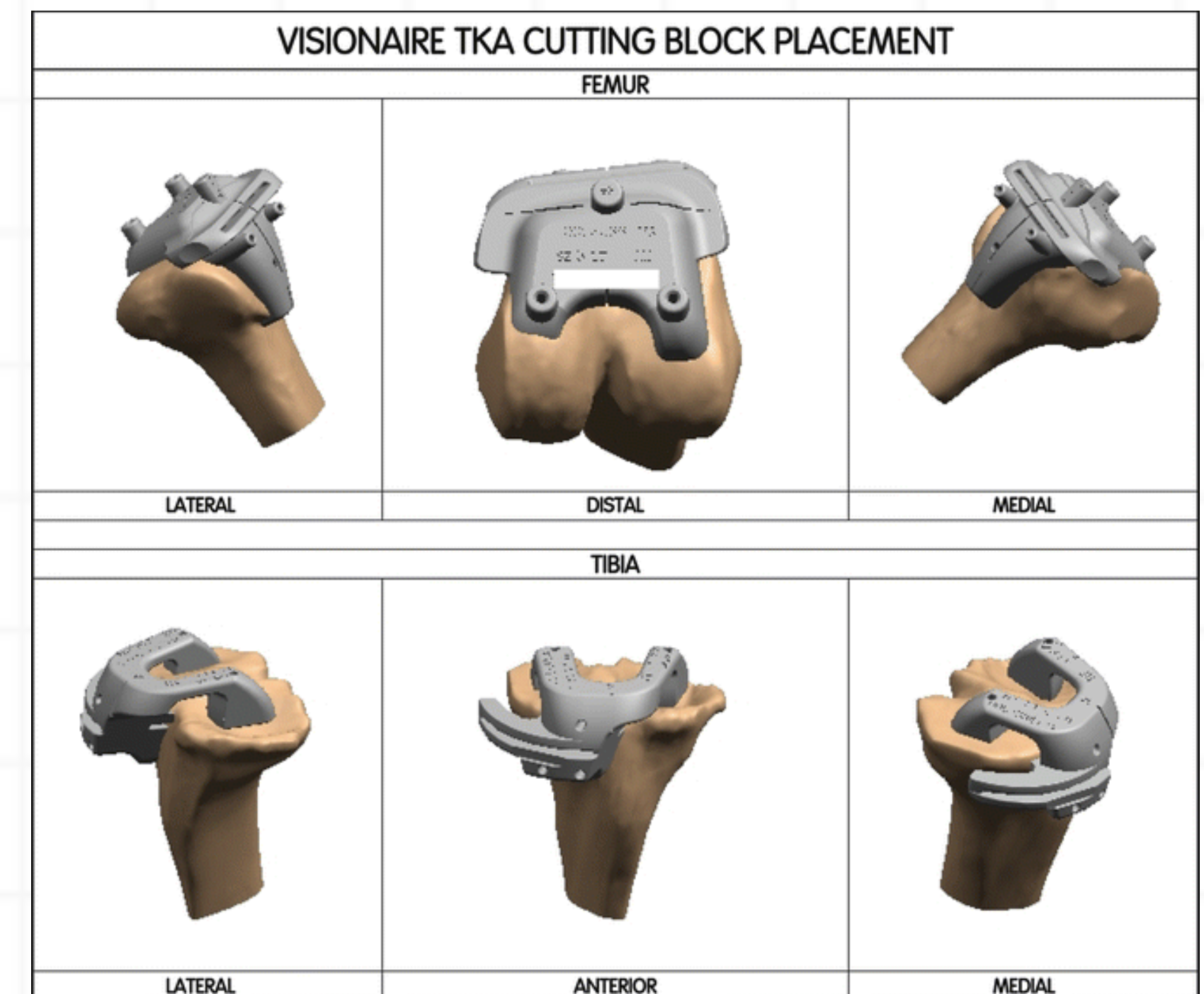
5. future perspectives

“MySolutions Personalized Ecosystem”

- designed for hip, knee, shoulder and spine surgeries
- pre-surgery: 3D imaging (CT* or MRI**)
- intra-surgery: personalized non-invasive guides



3D planning



Personalized guides

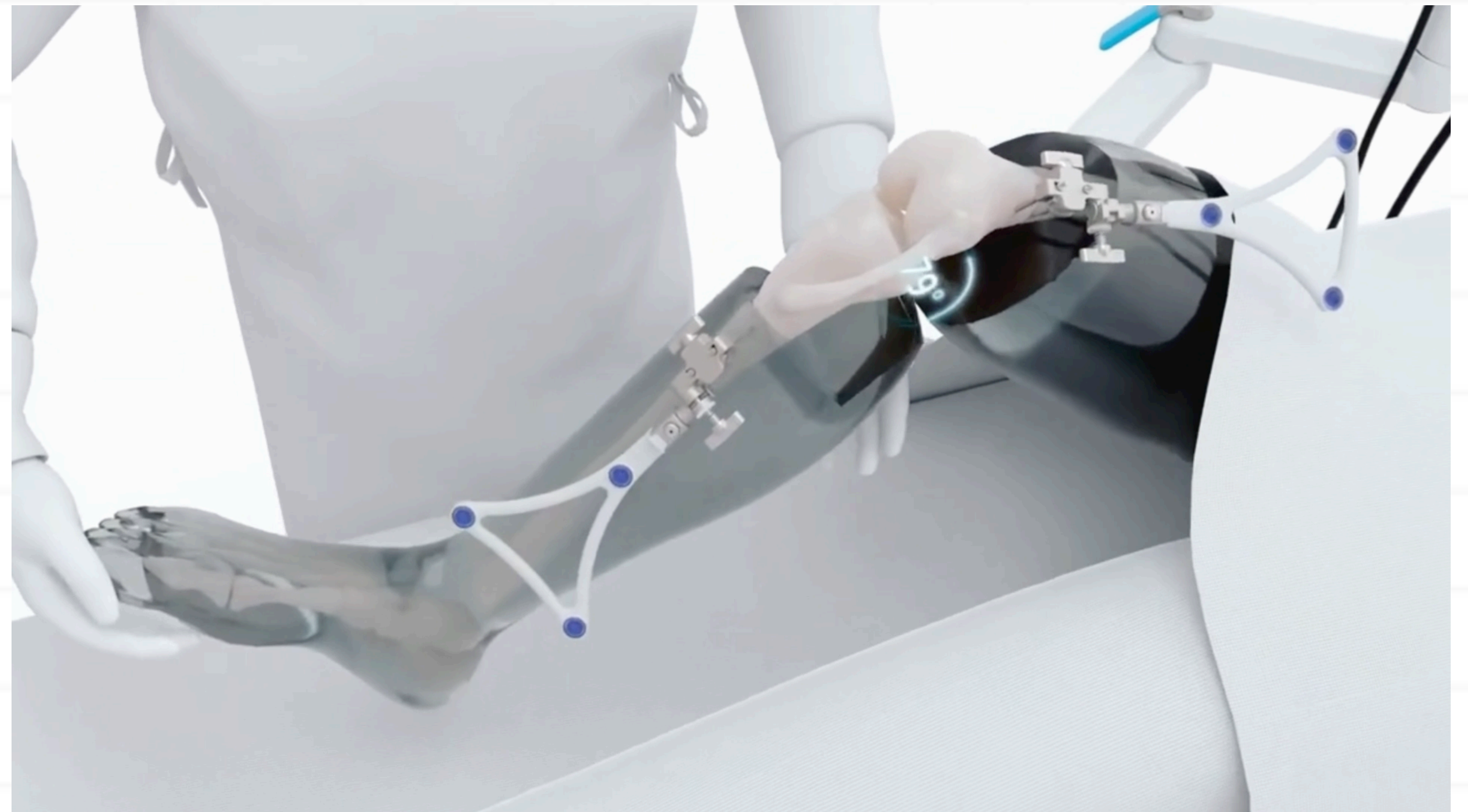
Surgical robots

5. future perspectives

“VELYS Robotic-Assisted Solution in Unicompartmental Knee Arthroplasty”



- designed for TKR and PKR
- generates a 3D model in direct time
- assists the surgeon thanks to robotic tools
- received 510(k) FDA Clearance in June 2024



Video of presentation: <https://www.youtube.com/watch?v=EU9CzO8ZHyE>

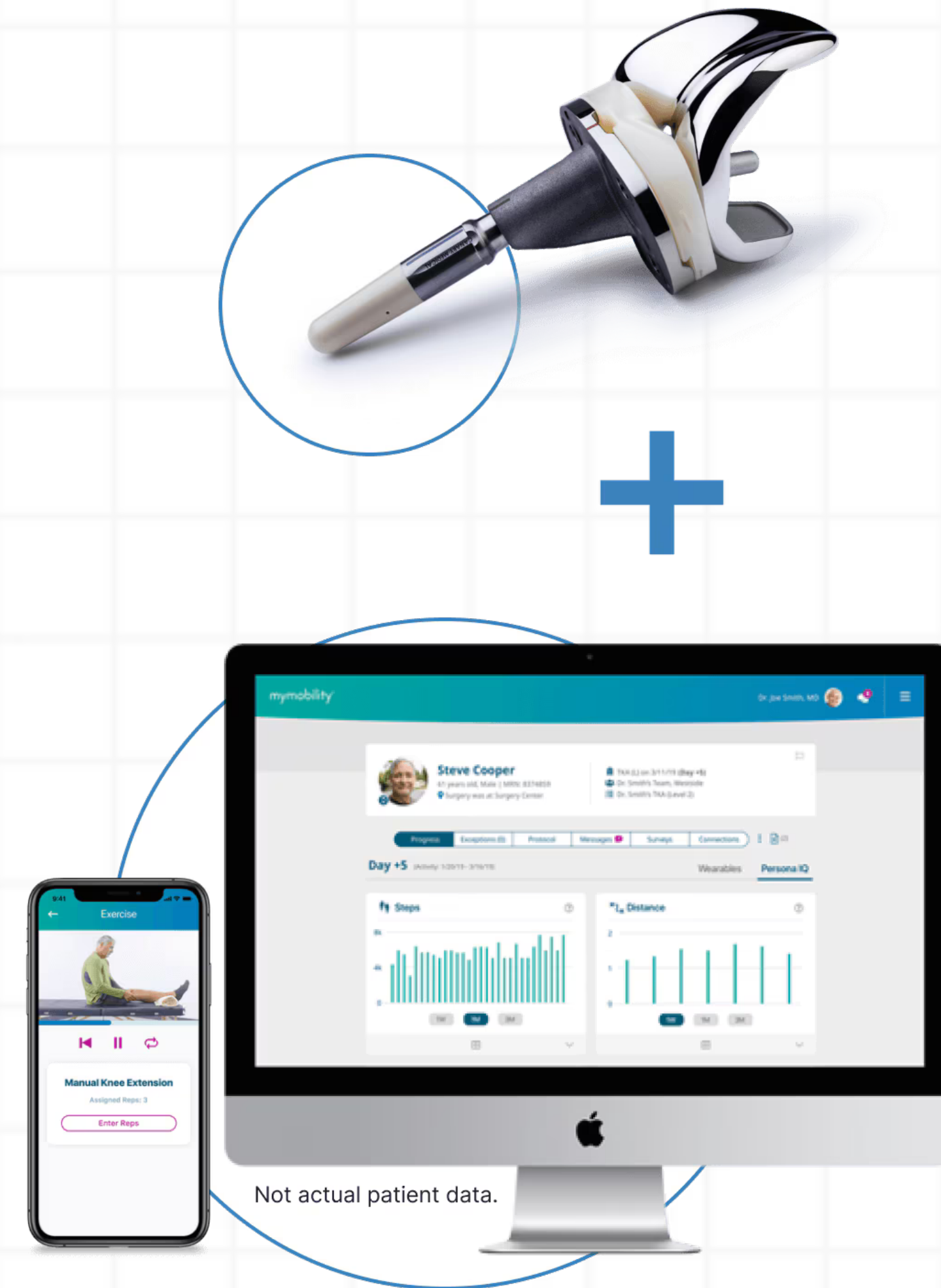
Smart orthopedics

5. future perspectives

"Persona IQ - The Smart Knee"



- connected to the implant
- provides post-operative kinematics metrics
- delivers a platform for both patients and physicians
- FDA approval in 2021



Thank you
any questions ?

