Smart Orthopedic Implants

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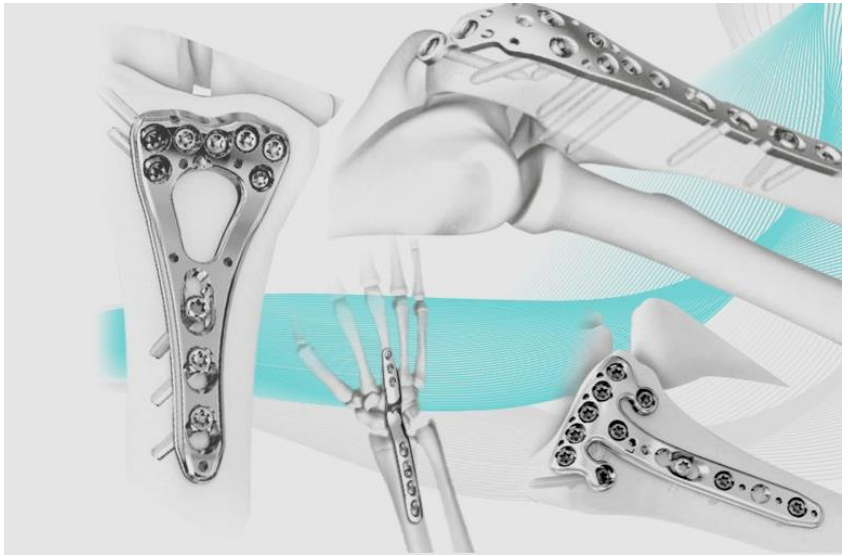
Introduction

- Orthopedic Implants: devices to support or replace bones and joints
- Smart Orthopedic Implants: sensors and data feedback
- Importance: Improve surgery and monitor recovery

Physiology aspects

- Orthopedic implants: replace or repair/support damaged bones or joints



- Requirements:
  - Biocompatibility
  - Mechanical strength
  - Durability

- Global health problem:
  - Osteoarthrisis: 528M people worldwide (increase 113% since 1990)
  - Fractures: 440M people

Technical description

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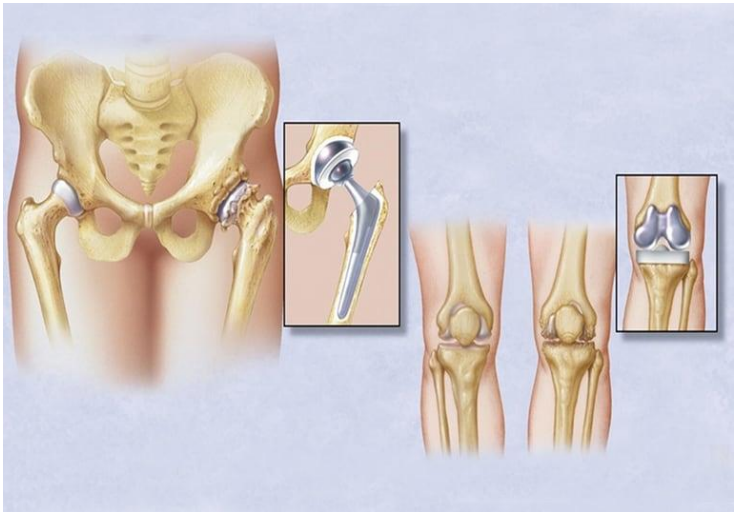
- Conventional OIs: no feedback



- Smart orthopedic implants:
  - Sensors
  - Power supply
  - Communication

- Used mainly for total knee arthroplasty (TKA), total hip arthroplasty (THA) , spine fusion and fracture fixation

Technical description

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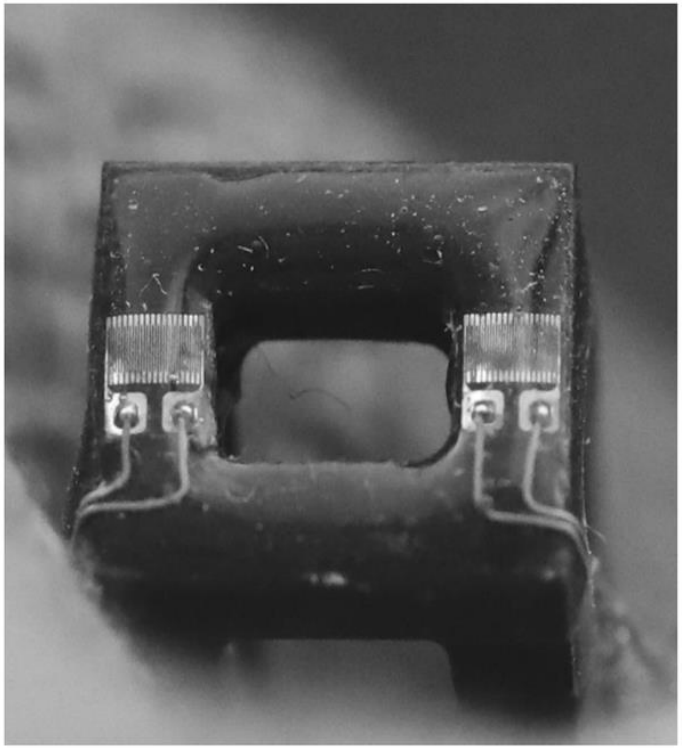
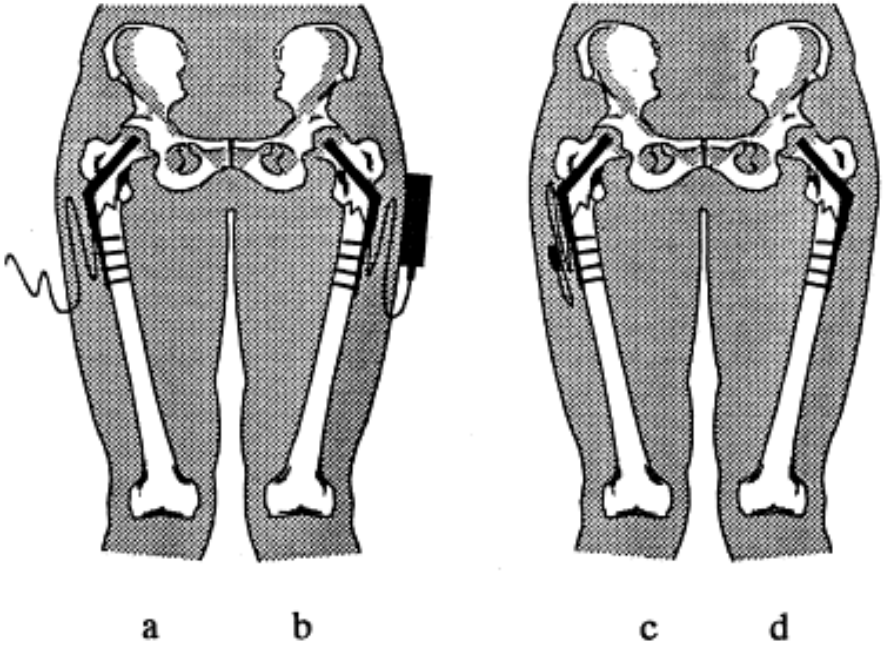
- Sensors:
  - Strain gage-based sensing since the 1960s
  - Pressure
  - Temperature
  - etc



Technical description

- Power supply and communication systems:
  - Percutaneous lead wires (a)
  - Telemetry transmitters powered by batteries (b)
  - Wireless and inductively powered (c; d, totally sealed)



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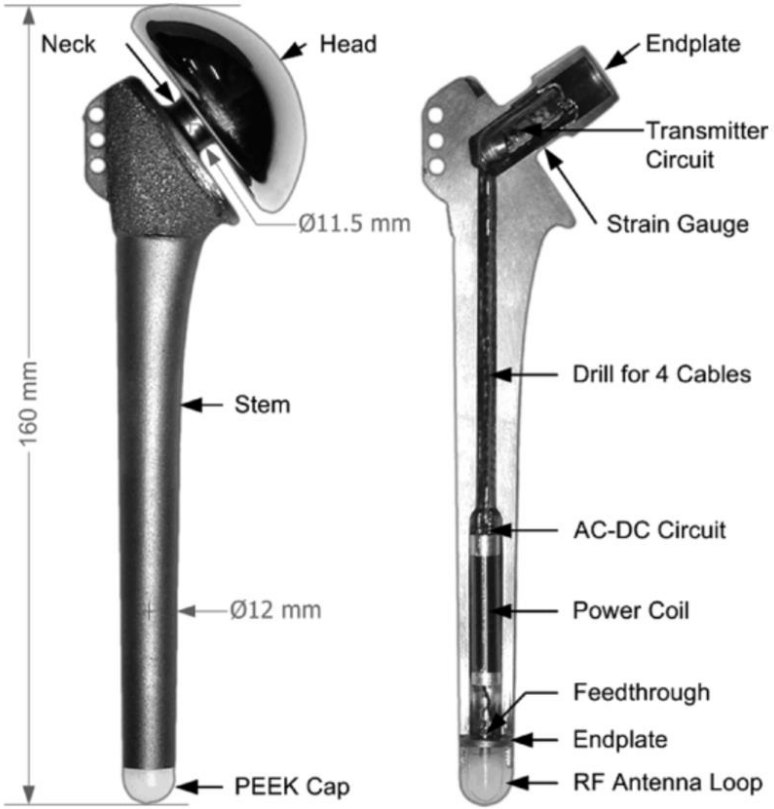

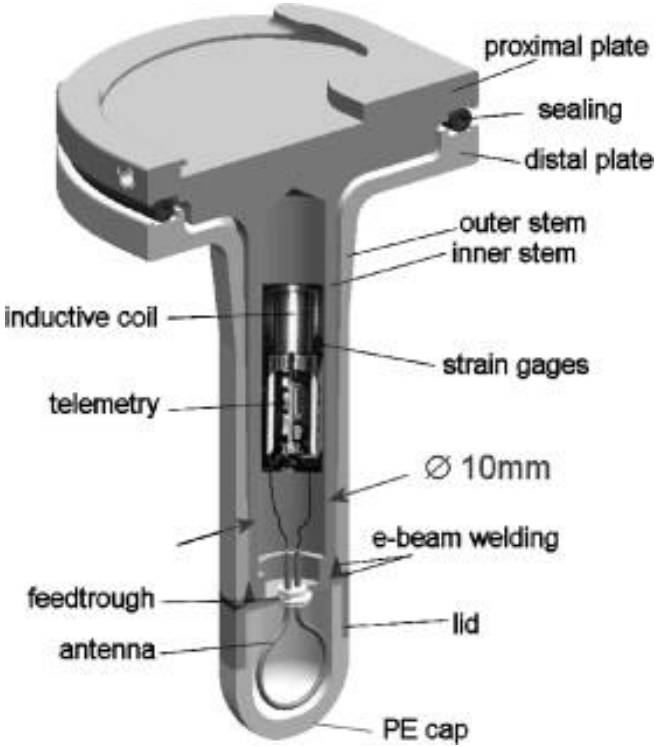

Advatages of Smart Orthopedic Implants

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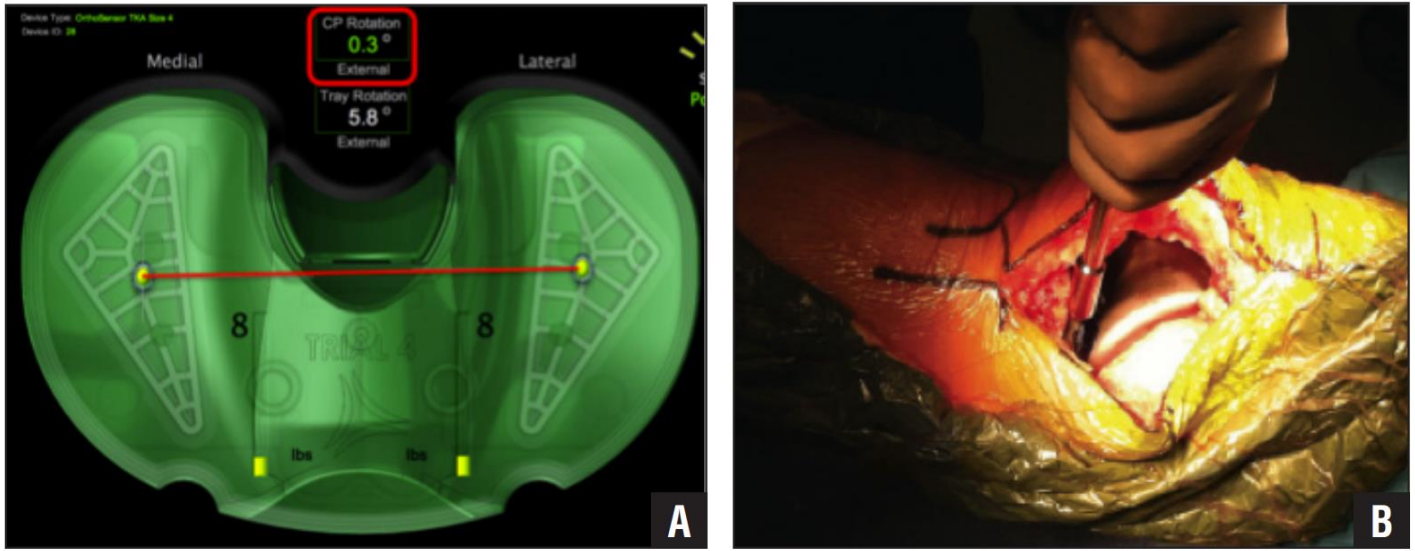
- For patient:
  - Personalized and improved rehabilitation
  - Reduced risk of complications
- For surgeon:
  - Intraoperative optimization
  - Postoperative monitoring
- For researchers and designers:
  - Improving future designs

Examples of use of Smart Orthopedic Implants

- Total Knee Arthroplasty (TKA):
  - Intraoperative use: improve ligament balancing
  - Postoperative monitoring: load and wear tracking avoids complications



VERASENSE (OrthoSensor) sensor as shown on the graphic user interface (A) and surgery (B)

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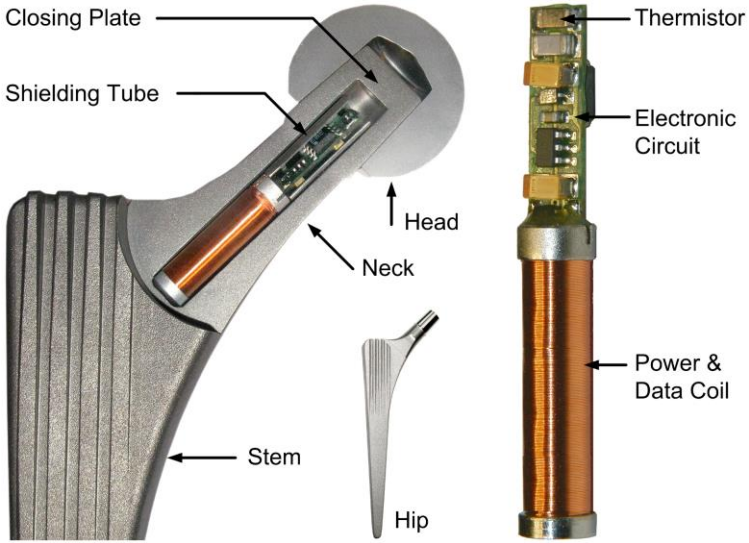
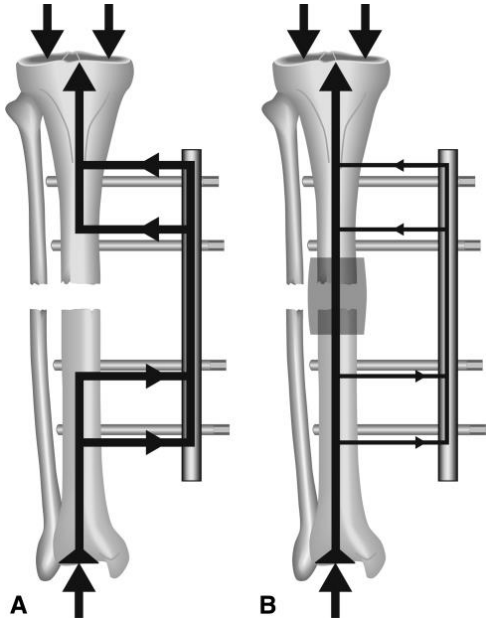
Examples of use of Smart Orthopedic Implants

- Total Hip Arthroplasty (THA):
  - Intraoperative use: ensure proper femoral head positioning
  - Postoperative monitoring: ensure stability and functionality of implant



Examples of use of Smart Orthopedic Implants

- Spine fusion: Assess fusion success without invasive tests
- Fracture fixation:
  - Adjusting patient activity to improve healing
  - Indication of consolidation and healing of the fracture



Medical Significance

- Better understanding of biomechanics
  - Analyze of in vivo data (dynamic joint stresses, fusion progress)
- Reduced complications
  - Detects misalignment, loosening, etc. avoiding failures
- Optimized care costs:
  - Reduces hospital visits, revision surgeries, etc.
- Better patient satisfaction

Notable trials

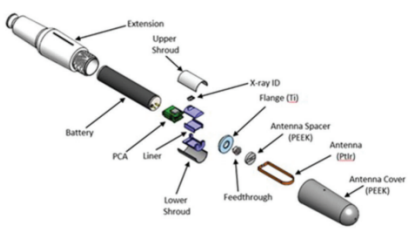
- 2020 - OrthoSensor VERASENSE™: FDA clearance when used with the Zimmer Biomet Persona Knee implant system (Persona).

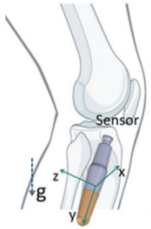
- Center of load indicators
- Load values
- Kinetic Tracking
- Wireless communication
- Calibration indicators
- Positional data
- Minimal-to-no change surgical technique

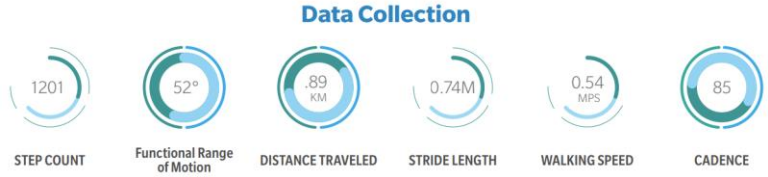
Notable trials

- 2021 - Zimmer Biomet Persona IQ®: FDA cleared for total knee replacement surgery.

SMART STEM	DATA TRANSMISSION	PHYSIOLOGICAL SENSORS	BATTERY
• Titanium & PEEK construction • PEEK allows data transmission	• Secure near-field connection to a base station, with secure wi-fi upload to the cloud	• 3D Accelerometer • Gyroscope	• Lithium carbon-monoflouride chemistry (Li/CFx) • Similar battery technology used in pacemakers





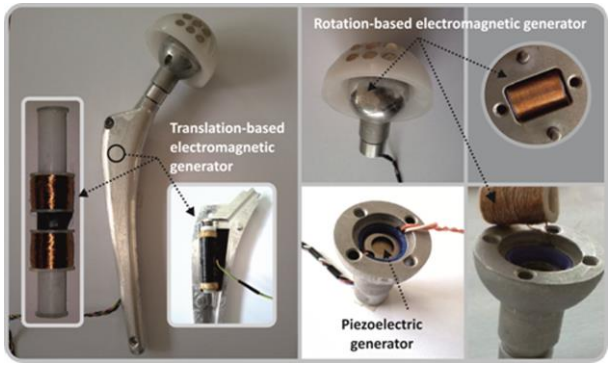


« Product » aspects

- Global costs:
  - Direct healthcare expenses
  - Loss of productivity
  - Premature retirement

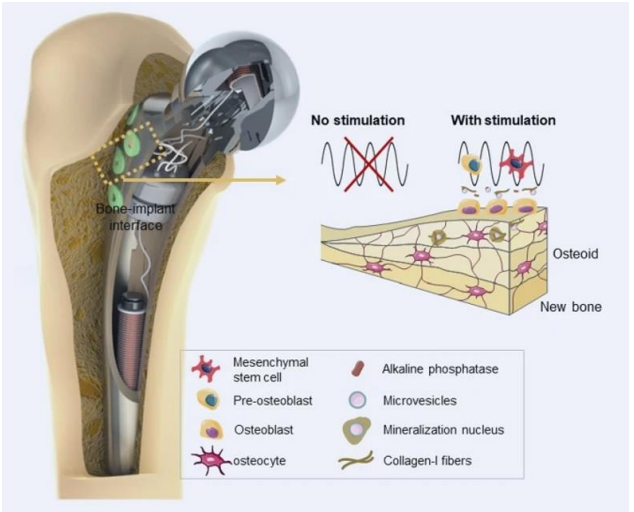
- Surgery demand grows
  - TKA and THA among the most common
  - Projections in the US:
    - THA increase of 176% by 2040 (659% by 2060)
    - TKA increase of 139% by 2040 (469% by 2060)

Future perspectives



- Power and communication
  - Energy harvesting devices
- Miniaturization

- Integration into traditional implants
- Bioelectronic multifunctional smart implants
- Regulatory approvals for clinical applications



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Conclusion

- Clinical utility of Smart Orthopedic Implants
- Strong potential to improve surgery and enable personal medicine
- Challenges remaining
- Mainly research for now

Questions?