

Sensors in Orthopaedics

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Disclosures

- ▶ **Co-Editor in Chief** | Canadian Journal of Surgery, OTA Patient Portal
- ▶ **Editorial Board** | OTA International, J Ortho Trauma
- ▶ **Partnerships** | Google

Corporate Ownership


- ▶ **NXTSens Microsystems Inc.** | Co-Founder
- ▶ **MY01 Inc.** | Co-Founder CMO
- ▶ **Cananose Inc.** | Co-Founder
- ▶ **ChemSense Tech Inc.** | Co-Founder CEO
- ▶ **Stathera Inc.** | Co-Founder
- ▶ **NXTSens Starter Inc.** | Founder CEO
- ▶ **Board/Committee Member** | Orthopedic Trauma Association, SICOT



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Sensors Are the New Pen and Paper

- ▶ Smart implants and digital health are not the future - they are the present
- ▶ Identify virtually any data point
- ▶ Overwhelming amount of data
- ▶ Transformative when used correctly



“Your cellphone has 10 (28) sensors, and your car has 400. But your body has none – that’s going to change.”

– Vinod Khosla

Real Time monitoring of patients with sensors is a key enabler of the future of healthcare

“The future of health care will be virtual, aided by sensor strategies and powered by predictive analytics. This will enable personalized decisions and, consequently, the delivery of the highest level of patient-centric care.”

– Future Care: Sensors, Artificial Intelligence, and the Reinvention of Medicine by Jag Singh



Data Never Sleeps 11.0

Domo has been keeping tabs on the world's data usage—in a minute—for over a decade now. What the numbers consistently show is that how we use data is always evolving—and that data isn't slowing down. We're also seeing some big changes. The rise of Artificial Intelligence (AI) is reshaping the way we communicate, work, and create. Digital payments continue to replace traditional transactions. Taylor Swift streams in countless headphones. And a rash of cybercrime grows alongside these digital experiences.

In Domo's 11th edition of Data Never Sleeps, we take the pulse of our digital age, where every click, swipe, and stream fuels an ever-expanding digital universe. These are not just numbers; they are the heartbeat of a world where data reigns supreme.



The world's internet population continues to grow significantly year-over-year. As of November 2023, the internet represents 5.2 billion people—approximately 64.6% of the global population. According to Statista, the total amount of data predicted to be created, captured, copied, and consumed globally in 2023 is 120 zettabytes, a number projected to grow to 181 zettabytes by 2025.

Global Internet Population Growth (IN BILLIONS)



As data grows and evolves, businesses need to grow and evolve, too. Domo helps you harness the power of data so you can change as quickly as the world changes and make data-driven decisions that set you apart from the crowd. Let Domo help you make sense of all the clicks, swipes, and shares so you can see the big picture that a lot of small decisions make.

Learn more at domo.com

SOURCES: PARTNERS, DUSTIN STOUT, DEMANDBASE, HOOTSUITE, BUSINESSOFFICE, DOORDASH, SOCIALPLOT, 2 | TWITTER.COM, SPINNA, PINKA, 2, THIRDMARKET, SPINA, COM, STATISTA, INNOVATIONS, NETWORK



Sensors supply data There Is a Lot of Data already... But the Tap Is Barely Open

- ▶ Internet traffic will be dwarfed by IoT and personal health data
- ▶ Thankfully, a lot of it is local traffic

IoT = Sensortech “fog” not the cloud

- ▶ “Every” device and person (and thing) is destined to have a unique identifier that communicates or interacts electronically with other connected things
- ▶ No need to “go to” the cloud

- ▶ **Medicine is in the mix**
- ▶ **Smart Implants will work here soon**



2025 Digital Health Landscape Funding

- ▶ 36 of 50 leading companies building AI-powered products
- ▶ Virtual and hybrid care firms have more than doubled
- ▶ Companies automating tasks so clinicians can focus on patients
- ▶ All depend on sensor data

FDA-Approved AI-Based Medical Technologies

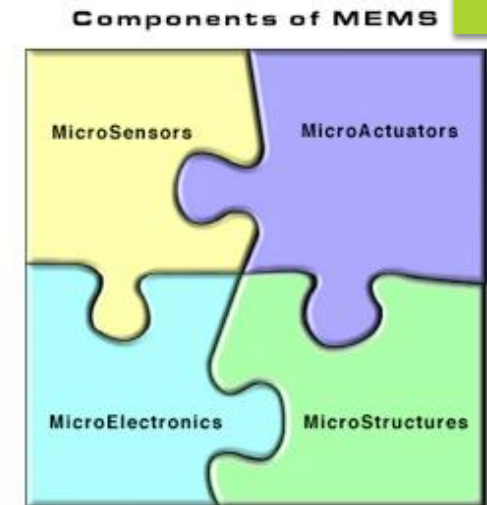
by Medical Specialty Categories



What Made This Revolution Possible – what drives AI

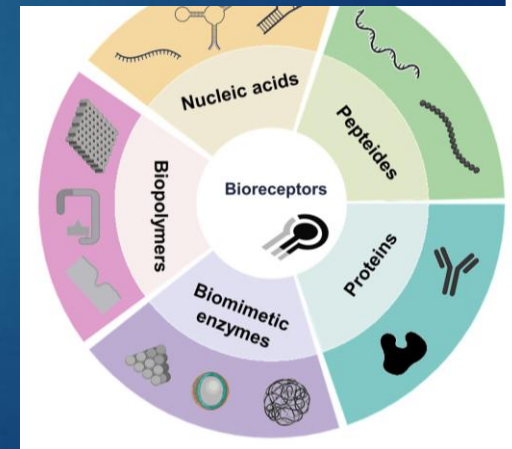
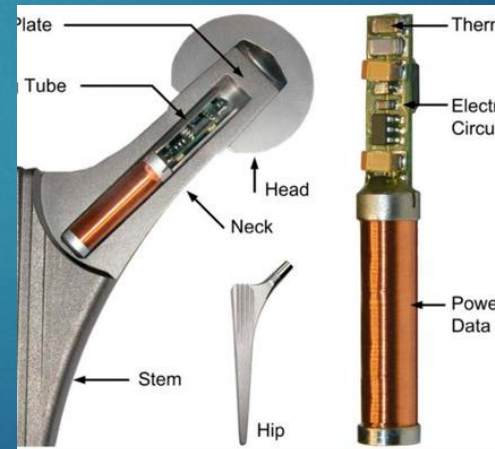
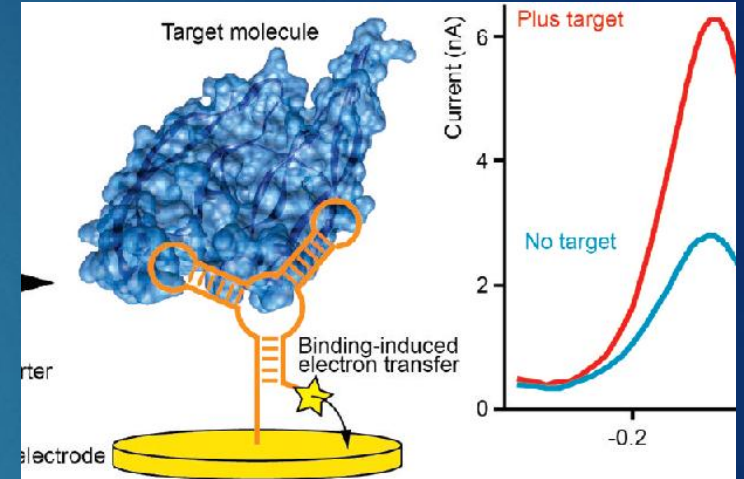
Cheap reliable sensors

- ▶ MEMS - small, reliable, low-power sensors manufacturable at scale
- ▶ Detect physical, chemical, and biological parameters
- ▶ Low-power wireless + IoT - continuous data from inside the body to the fog/cloud



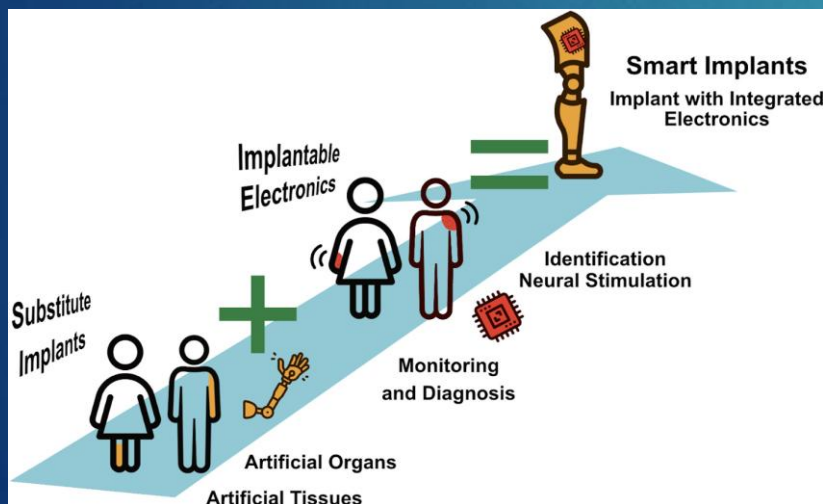
What Can Sensors Actually Detect?

- ▶ Physical - pressure, strain, motion, acceleration, temperature
- ▶ Chemical - pH, gas composition, metabolites
- ▶ Biological - cell activity, infection markers, healing signals



Big Ortho Is Buying In - The Acquisition Wave

















- ▶ 2020: Exactech acquires Muvr Labs - wearable motion sensors, patient dashboard
- ▶ 2021: Stryker acquires OrthoSensor - VERASENSE, MotionSense, OrthoLogIQ platform
- ▶ Ongoing: Zimmer Biomet + Canary Medical - CHIRP smart knee implant
- ▶ 2026: Maxx Orthopedics acquires TracPatch® - real-time recovery tracking
- ▶ Every major orthopaedic company has made a sensor acquisition?



Smart Corporate Strategy

Maxx Orthopedics Acquires TracPatch®, Expanding QRS® Platform into a Fully Integrated Recovery Ecosystem



- 

2003
 - Initial research of the Freedom Knee concept started at the Harris Orthopaedics Laboratory at Massachusetts General Hospital
 - Conceptualization of company
 - Idea: designing a hi-flex knee based around anatomy-optimized sizing
- 
2007
 - Testing of Freedom Knee at Orthopedic Research Laboratory (ORL)
 - Funding received, created infrastructure support, and started Asia distribution capabilities
- 
2008
 - Testing concludes, and data sent to US FDA
- 
2009
 - Received US FDA Approval
 - Release of Freedom Knee in India
- 
2010
 - Release of Freedom Knee in US
 - Release of Freedom Knee in other Asian countries
- 
2011
 - Release of Freedom Knee in Europe
- 
2012
 - Approval of Freedom Knee in China
 - Approval of Stemmed Tibia option in US, Europe, India
- 
2015
 - Approval of PCK Revision system and Freedom Renew Knee in US
- 
2016
 - Approval of Freedom Uncemented Femur in the US
 - Release of PCK Revision system in US
- 
2017
 - Release of Primary PCK in US
 - Release of PCK Revision system in Asia and Europe
- 
2019
 - Release of Libertas Hip in US
 - Release of Freedom Knee Ultra-Congruent Liners
 - Approval of Primary PCK Liners in US
 - FDA Clearance of Freedom® Primary PCK Femoral Component
- 
2020
 - Release of Libertas TR Stem in US
 - FDA Clearance of Freedom® Titan Knee System
 - Launch of Libertas® Taper Reduction (TR) Hip System
- 
2021
 - Pre-market, global feasibility study begins with the PEEK-OPTIMA™ Femoral Component
 - Launch of QRS® Quick Recovery Solutions for ASCs
 - First Primary Total Knee Arthroplasty procedure with PEEK-OPTIMA™ Femoral Component based on Freedom® Primary Knee System
 - Launch of Quick Recovery Solutions (QRS®) for Ambulatory Surgery Centers (ASC)
- 
2022
 - Release of Freedom Titan Knee in US
- 
2024
 - Partnership with THINK Surgical, Inc.

Strategic Implications for the Field

- ▶ Digital ecosystems are the endgame - intraoperative + long-term recovery analytics on one platform
- ▶ Robotic integration - sensors feeding real-time data into surgical robots
- ▶ Competitive displacement -
 - ▶ OrthoSensor acquisition disrupted competitors overnight
- ▶ Smart implants are the destination - monitoring healing, infection, and stability long-term



Four Domains of Application in Ortho

- ▶ **Wearables** - pre-op, post-op, rehab (TracPatch, MotionSense)
- ▶ **Intraoperative** - during surgery (VERASENSE knee balancing, AR, Robotics)
- ▶ **Indwelling** / Smart Implants - long-term post-op (Persona IQ, smart rods)
- ▶ **mHealth** – multiple sensors aligned for clinical care
- ▶ Each domain has different requirements for power, data transmission, and biocompatibility

Wearables: The Easiest to Grasp

- ▶ You already have one
- ▶ Track range of motion, step count, gait metrics, exercise adherence
- ▶ Enable remote patient monitoring without visits
- ▶ Generate objective recovery data surgeons previously had to estimate (Prehab, Rehab)
- ▶ The question is no longer whether patients will use them - it's how we use the data

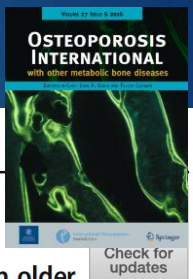


Osteoporosis International (2020) 31:1333–1340
<https://doi.org/10.1007/s00198-020-05359-3>

ORIGINAL ARTICLE

Current level of technology use, health and eHealth literacy in older Canadians with a recent fracture—a survey in orthopedic clinics

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Intraoperative: AR and Surgical Navigation

- ▶ **Robotic integration** - Mako SmartRobotics combines sensor feedback with haptic constraints
- ▶ **AR navigation headsets** - Augmedics X2 received FDA clearance November 2025
 - ▶ Real-time 3D anatomical overlay during spine surgery
 - ▶ Image-guided navigation - sensor arrays track instrument position relative to anatomy
- ▶ **Fluoroscopic navigation** - computerized C-arm tracking for IM nailing
- ▶ **The OR becomes a sensor-rich environment where every tool position is tracked and acted on**



INDWELLING: Smart Implants Have Left the Lab and the OR

- ▶ Active clinical use as of early 2026
- ▶ Total knee arthroplasty - objective gait and recovery data previously unavailable
- ▶ Spinal fusion - load monitoring and fusion confirmation without repeat imaging

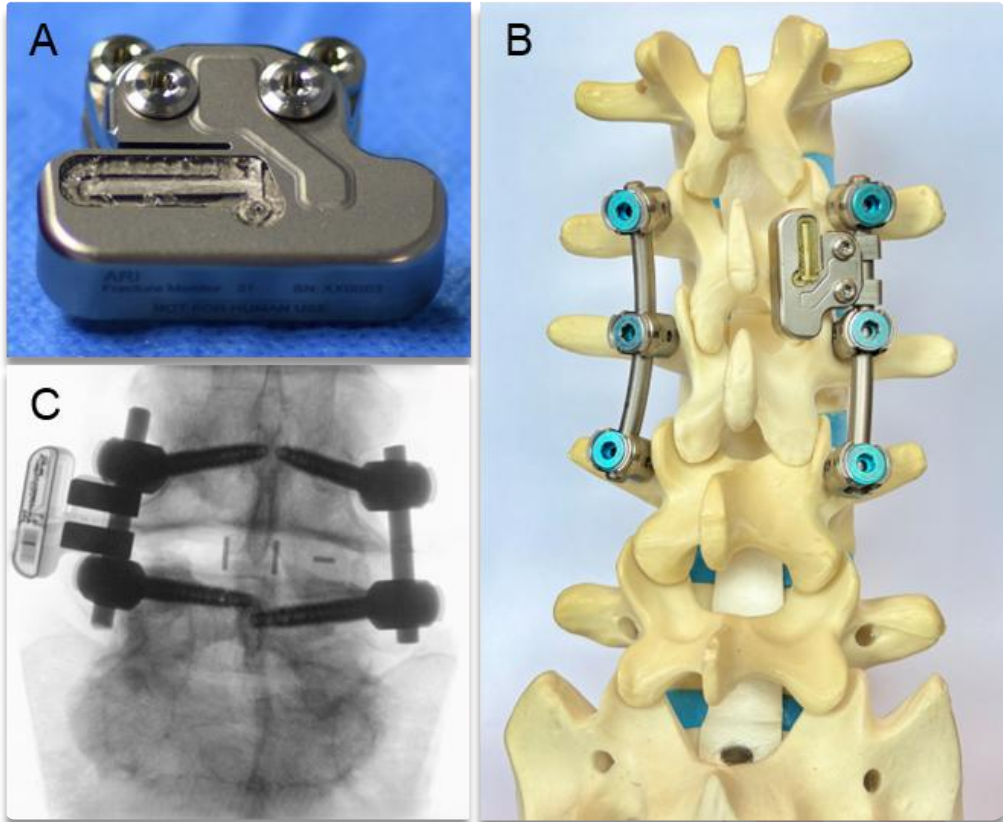


Smart Knee: Persona IQ® (Zimmer Biomet + Canary Medical)

- ▶ Canturio sensor captures step count, walking speed, gait - passively and continuously
- ▶ No patient action required
- ▶ Multicenter cohort study ongoing (NCT06089291)
- ▶ AAOs 2026: lower revision rates (0.13% vs 1.0%) and lower infection rates vs controls
- ▶ Gait changes detectable 2–3 days before clinical infection diagnosis



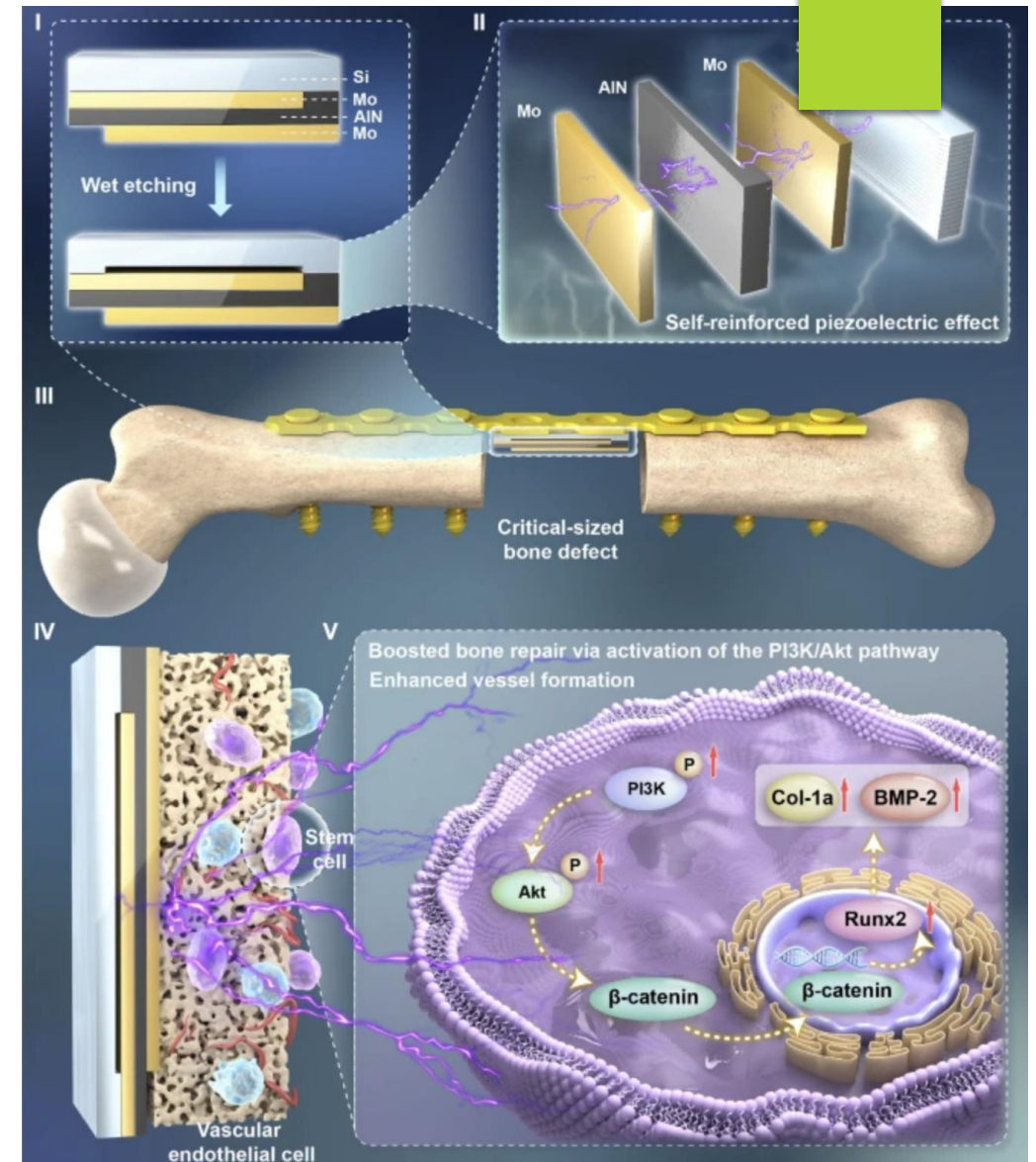
Smart Spine: The Next Major Frontier



- ▶ Smart rods and vertebral body replacements use strain gauges, thermometers, accelerometers
- ▶ Small-scale clinical studies - data published 2025
- ▶ Bone fusion monitoring entering wider trial enrollment 2025–2026
- ▶ IntelliRod: sensor clamps onto spinal fusion implant, transmits fusion data post-op
- ▶ Goal: reduce need for serial X-rays and CT scans

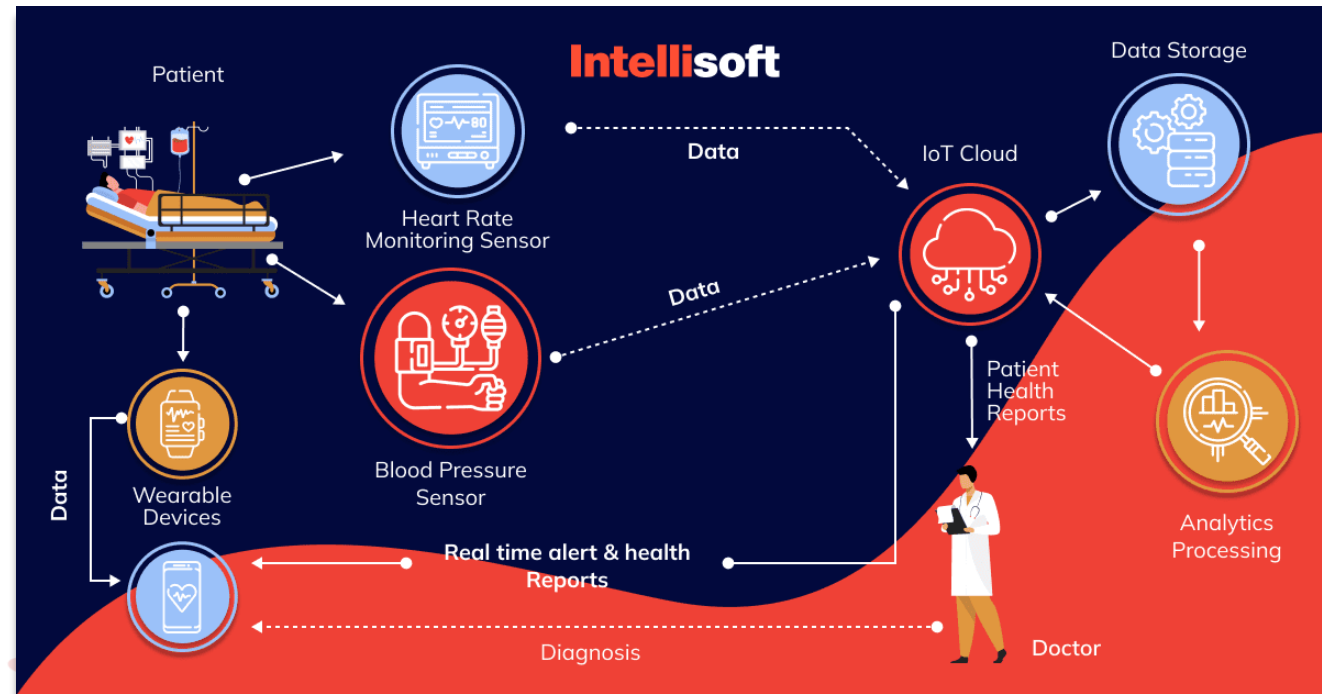
Emerging Technologies in the Pipeline

- ▶ Bioresorbable sensors
- ▶ Piezoelectric implants - walking forces converted to electrical energy, stimulate bone growth + ?antimicrobial
- ▶ AI-driven diagnostics - sensor data analyzed to predict outcomes



mHealth: The Fourth Domain

- ▶ Multiple sensor sources into one clinical interface
- ▶ Passively monitor hundreds of recovering patients
- ▶ Structured datasets for outcomes research and AI training
- ▶ Patient or Physician -facing - physio reminders, progress tracking, medication adherence
 - ▶ Examples: ReHub, BPMpathway, OrthoLogIQ, MY01 app



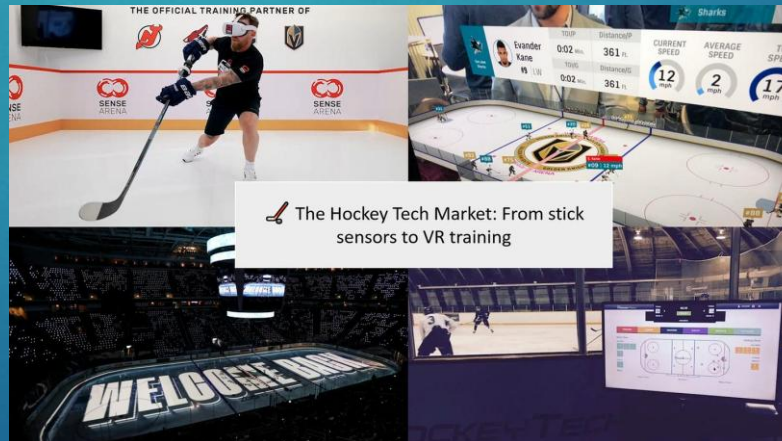
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Continuous Perfusion Monitoring: What the Data Volume Gives

- ▶ Obvious MY01 is part of this wave of data acquisition
- ▶ Continuous monitoring
- ▶ Not an incremental improvement - a fundamentally different type of clinical information
- ▶ Enables trend detection, early warning, and proactive care

Sports Medicine and Injury Prevention: First to the plate

- ▶ Motion analysis wearables
- ▶ Athlete load monitoring
- ▶ Rehabilitation feedback - objective gait and ROM data
- ▶ Return-to-sport criteria - sensor-based objective thresholds replacing clinical estimation
- ▶ Previously impossible without full biomechanics laboratory



What Is Slowing Adoption

- ▶ Regulatory:
 - ▶ 510(k) substantial equivalence dilemma for novel sensors
 - ▶ De Novo and Breakthrough Devices pathways exist but are slower
 - ▶ Frameworks lag AI-driven sensor outputs
- ▶ Reimbursement:
 - ▶ sensors often not covered - hundreds to tens of thousands of dollars
 - ▶ insurers require outcome evidence at equal or lower cost
- ▶ Data and privacy:
 - ▶ encryption adds power and system complexity
 - ▶ ownership, consent, and secondary use remain unresolved
- ▶ Equity:
 - ▶ rural and lower-income patients lack connectivity or digital literacy
- ▶ Treatment Inertia
 - ▶ Early adopters are harder to find especially in arthroplasty

Closing Summary

- ▶ Sensors are the new data collection standard - not a novelty
- ▶ Intraoperative sensing industry is consolidating rapidly - the window for innovation is now
- ▶ Smart implants are generating data that changes clinical decisions in real time
- ▶ Proven that continuous data leads to earlier diagnosis / better outcomes



THANKS

QUESTIONS?