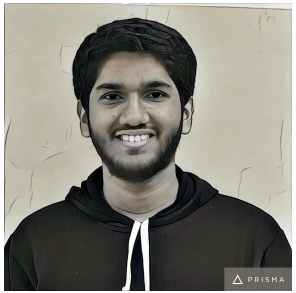
Image Guided Surgery

Team 1 : Orthopaedic Surgery

Technische Universität München

Hello, World!



Wasiq Rumaney
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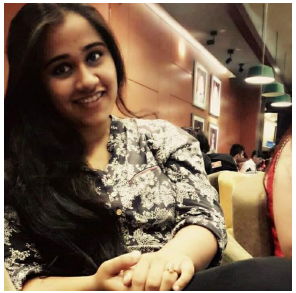

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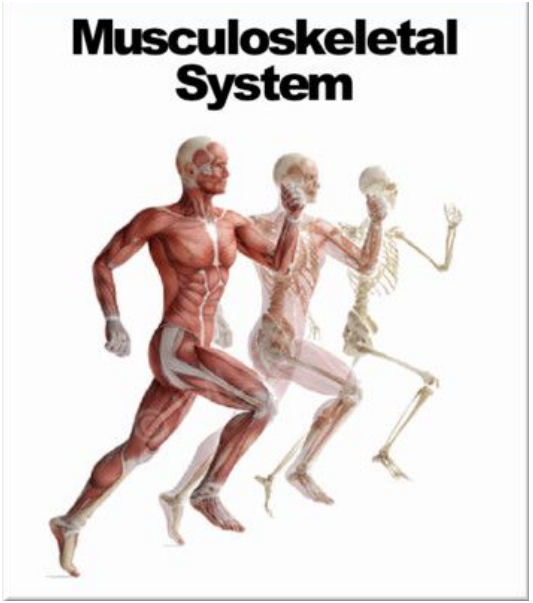
What we are gonna talk about...

- Orthopaedics Domain: Facts and Figures, Statistics
- Major tasks of an Orthopaedic Surgeon
- Major procedures
- Available IGS solutions (Commercial)
- Available IGS Solutions (Research)
- State-of-the-Art Research
- Problem Areas
- Future Research Areas
- Summary

Orthopaedics Domain



A medical specialty that focuses on the

- diagnosis
- correction
- prevention
- treatment

....of

Musculoskeletal System

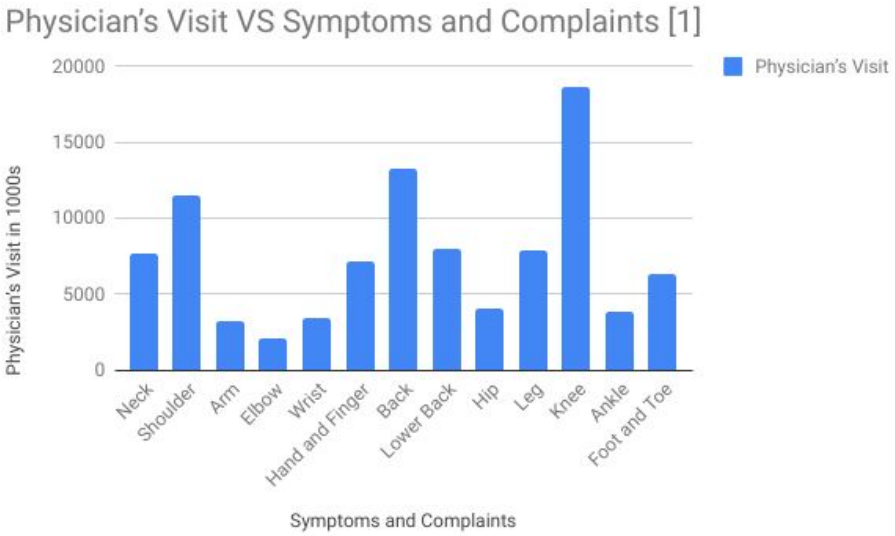
- bones, joints, muscles, ligaments, tendons, nerves and skin

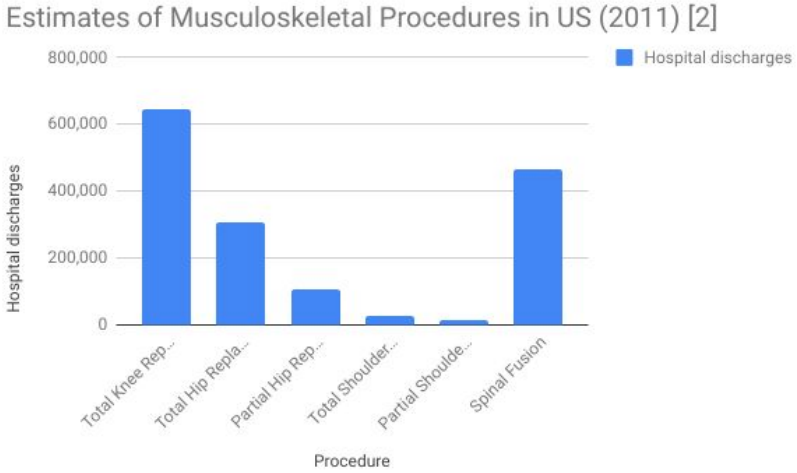
Orthopaedics: Quick facts and figures*

- Average age of practising orthopaedists: 55.24 years
- Most frequently cited areas
  - Sports medicine
  - Total joints
  - Hands
- Orthopaedists perform average of 30 procedures per month

*https://www.aaos.org/uploadedFiles/PreProduction/Research/Research_Tools/orthocensus/2016%20Census%20Final%20-%20Public%20Quick%20Facts.pdf. Accessed 08 Nov 2018.

Orthopaedics: Interesting Statistics

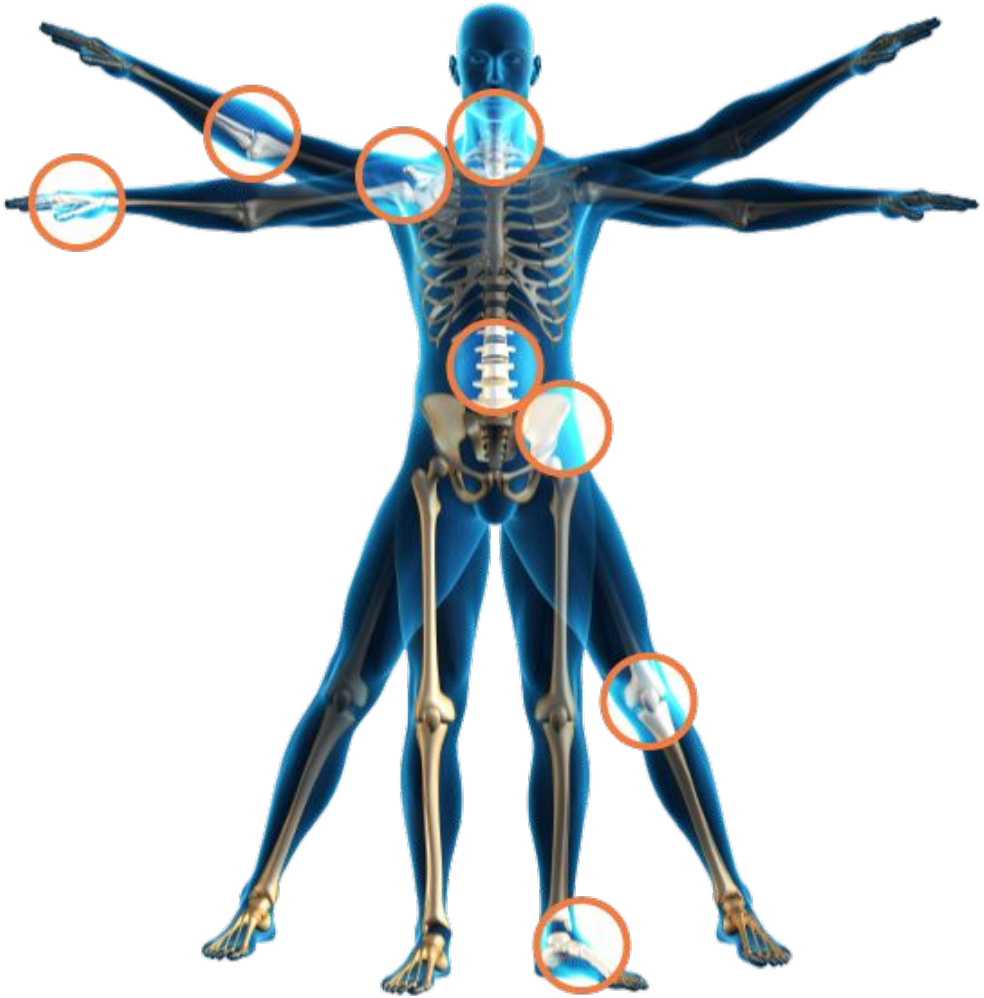




1. *Department of Research & Scientific Affairs, American Academy of Orthopaedic Surgeons. Physician Visits for Musculoskeletal Symptoms and Complaints. http://www.aaos.org/research/stats/patientstats.asp . Updated November 2013. Accessed 08 Nov 2018.*
2. *Department of Research & Scientific Affairs, American Academy of Orthopaedic Surgeons. Annual Incidence of Common Musculoskeletal Procedures and Treatment. http://www.aaos.org/research/stats/CommonProceduresTreatments-March2014.pdf . Published March 2014. Accessed 08 Nov 2018.*

Major tasks of an Orthopaedic surgeon

DIAGNOSIS	TREATMENT	REHABILITATION	PREVENTION
Arthrography Blood tests CT scan Discography Doppler ultrasound Flexibility tests Muscle tests MRI X-rays Palpation Venography	Medication supplements to strengthen joints or minimize pain Exercise Casting and splinting Surgery	Exercise Physical therapy to restore movement, strength and function	Exercise Balanced diet Healthful weight



Major procedures

Arthroscopy

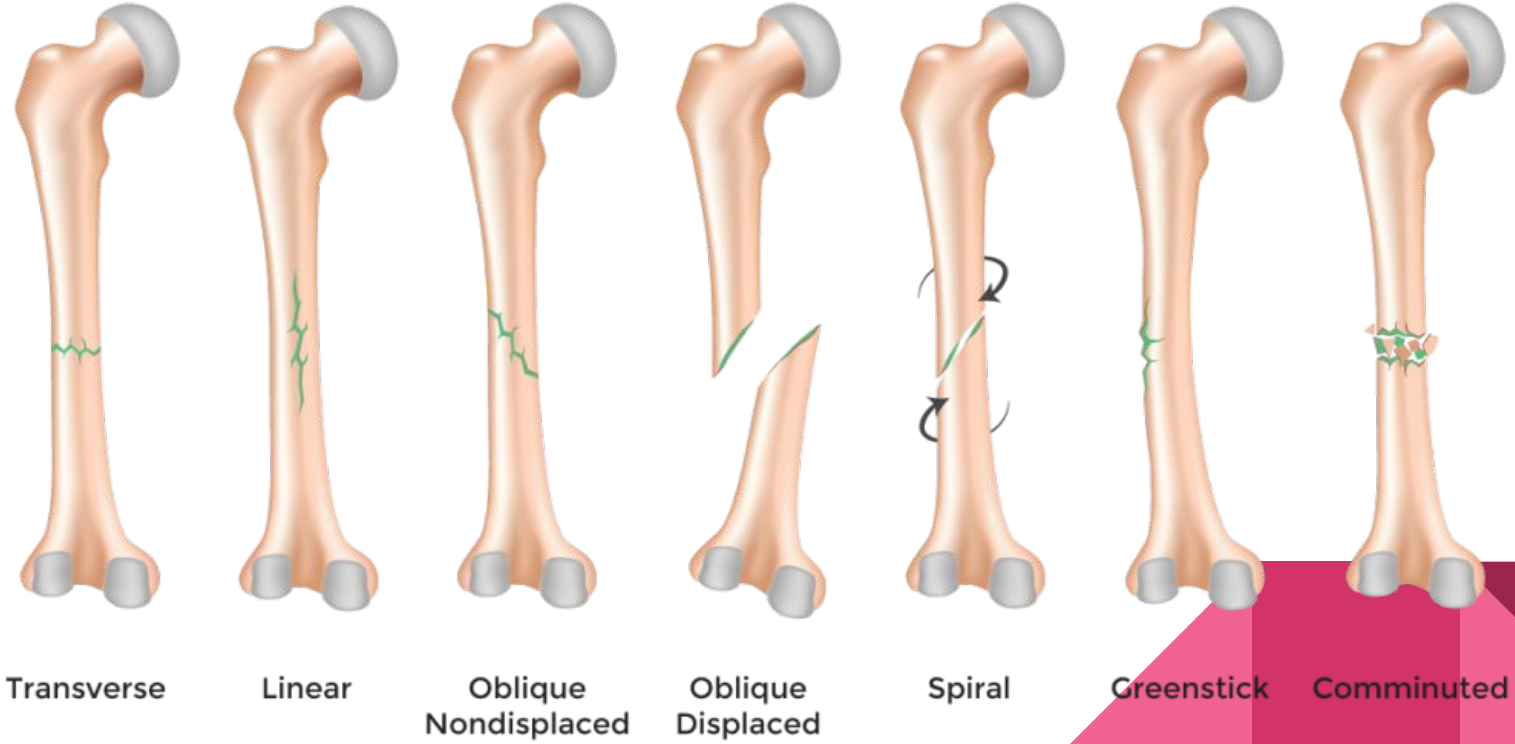
Spine fusion

Joint replacement

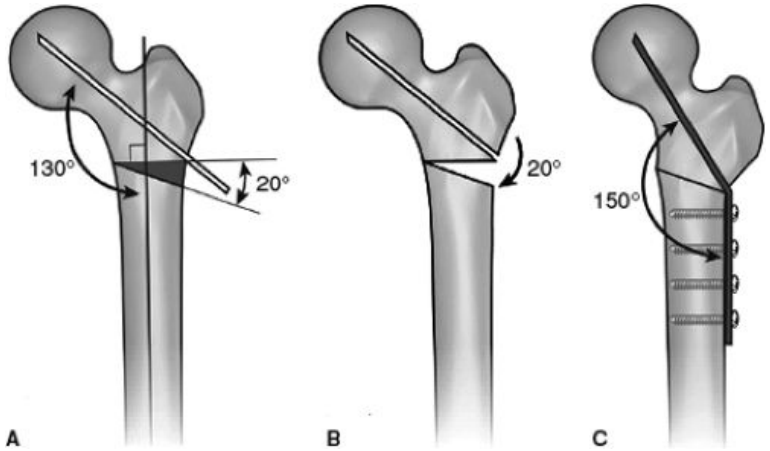
Fusion of bones

Debridement

Major procedures – bone fracture repair



Major procedures – Osteotomy



Available IGS solutions (Commercial)

- Computed Tomography (CT) scanners
- Ultrasound Systems
- Magnetic Resonance Imaging (MRI)
- X-ray Fluoroscopy
- Positron Emission Tomography (PET)
- Single Photon Emission Computed Tomography (SPECT)

Computed Tomography (CT) scanners

Source: https://orthocentre.co.nz/

Texas Orthopedics, Sports and Rehabilitation Centre

X-ray orthopedic medical CAT scan of painful knee meniscus injury leg in traumatology hospital clinic

Ultrasound Systems

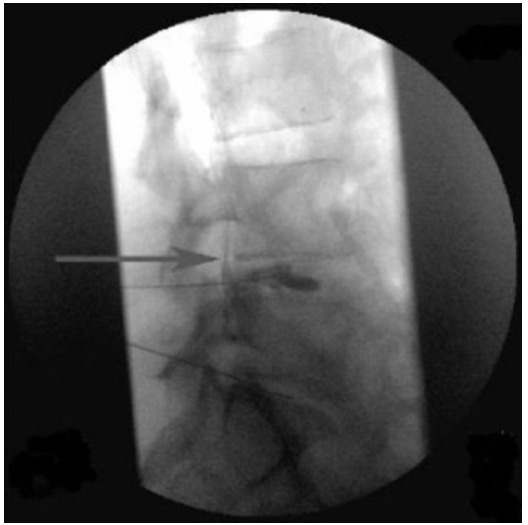
Magnetic Resonance Imaging (MRI)

Siemens Skyra 3T MRI Scanner

Siemens Biograph mMR hybrid system

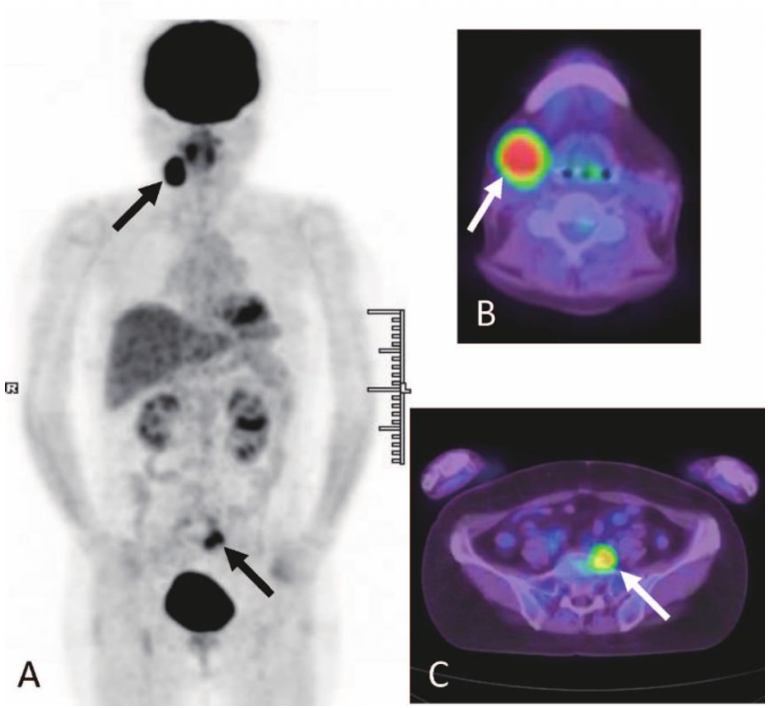
X-ray Fluoroscopy

Siemens' Cios mobile C-arm system.



https://www.cfaortho.com/patient-services/imaging/fluoroscopic-injections

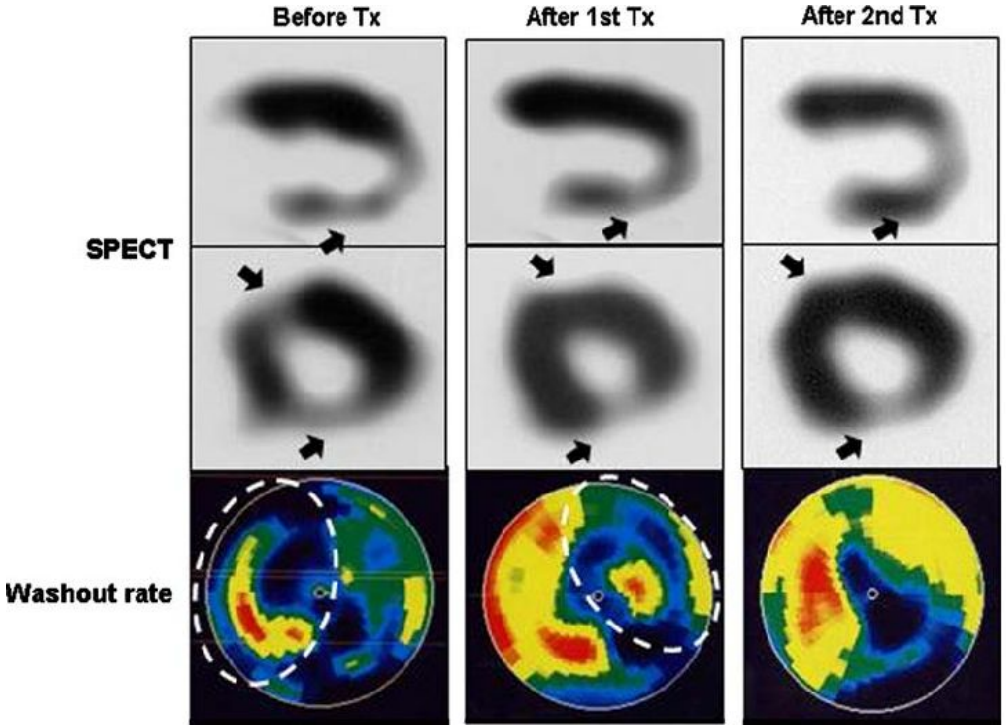
Positron Emission Tomography (PET)



Positron Emission Tomography Facility, The Iowa Institute for Biomedical Imaging

Tanaka, Kae & Harada, Hiroyuki & Kayamori, Kou & Omura, Ken. (2015). Chronic Sclerosing Sialadenitis of the Submandibular Gland as the Initial Symptom of IgG4-Related Disease: A Case Report. The Tohoku journal of experimental medicine. 236. 193-8. 10.1620/tjem.236.193.

Single Photon Emission Computed Tomography (SPECT)



Siemens Symbia Intevo Bold SPECT/CT

Shimokawa, Hiroaki & Ito, Kenta & Fukumoto, Yoshihiro & Yasuda, Satoshi. (2008). Extracorporeal cardiac shock wave therapy for ischemic heart disease. Shock Waves. 17. 449-455. 10.1007/s00193-008-0122-5.

Available IGS Solutions (Research)

- Evolved around two decades ago.
- (CAOS) module : real-time feedback through a virtual scene of the situs presented on a display device, employment of surgical robots.
- Components Involved:
  a. A therapeutic object [(TO), target of the treatment]
  b. A virtual object [(VO), virtual representation in the planning and navigation computer]
  c. Navigator [links both objects]

There are 3 methods of navigation used to carry out the surgery

CT-Based: utilizes CT imaging to construct a 3-D* model of the patient's anatomy to guide the surgeon

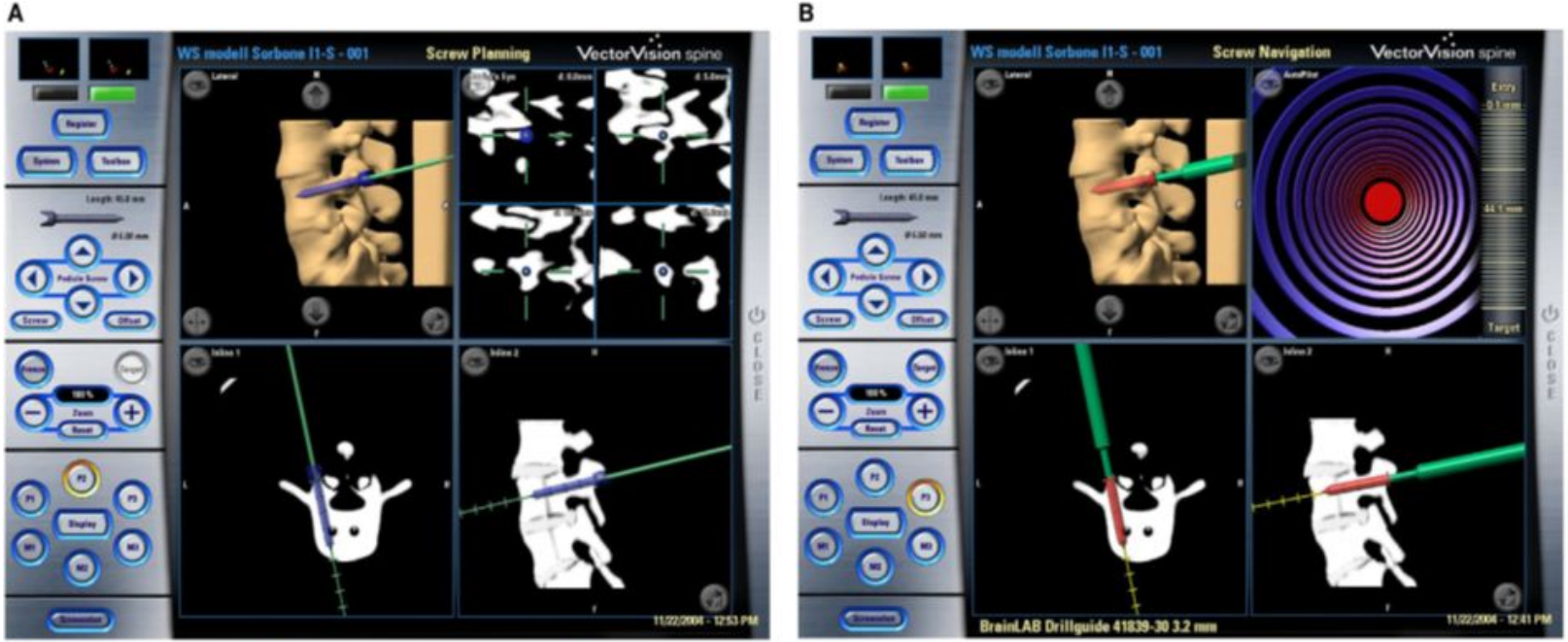


FIGURE 1 | Example of CT-based navigational feedback. These screenshots show a CT-based CAOS system during pre-operative planning (A) and intra-operative navigation (B) of pedicle screw placement (Courtesy of BrainLAB AG, Munich, Germany).

Fluoroscopy-Based: allows the surgeon to take multiple fluoroscopic images (at different angles) of the surgical site

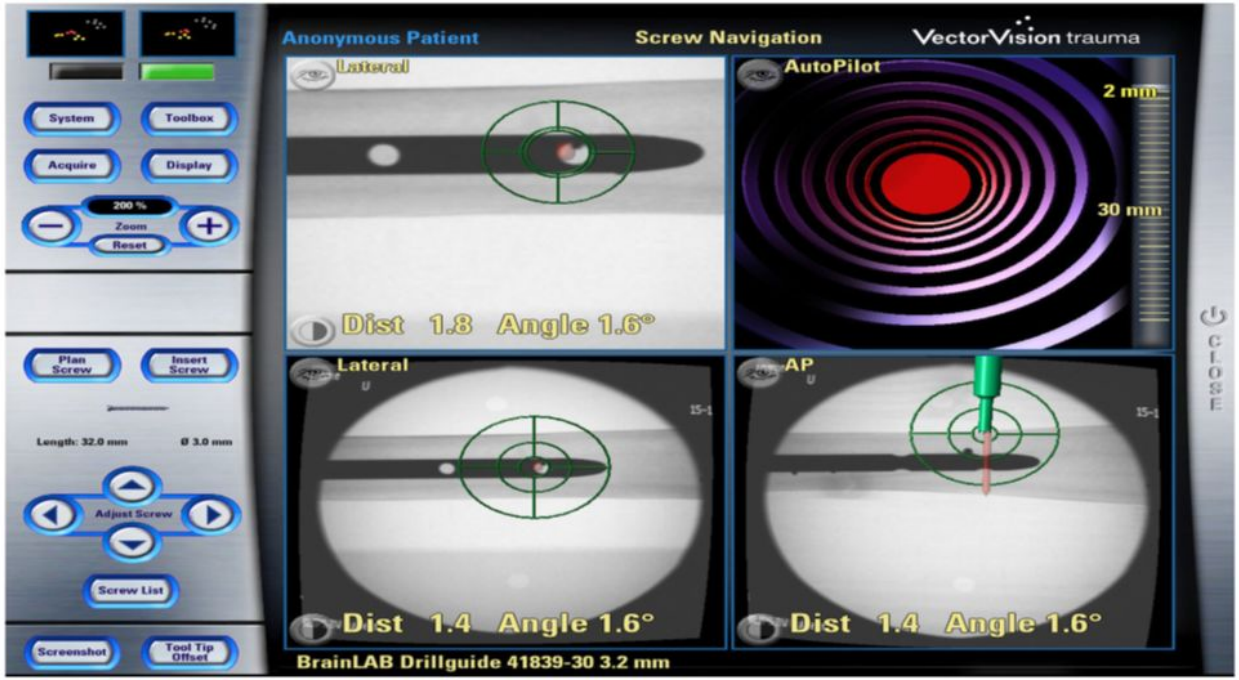


FIGURE 2 | Example of Fluoroscopy-based navigation. This screenshot shows the fluoroscopy-based navigation for distal locking of an intramedullary nail (Courtesy of BrainLAB AG, Munich, Germany).

Imageless: computer constructing a digitized anatomical model of the area of interest by using results of the patient's orthopedic tests

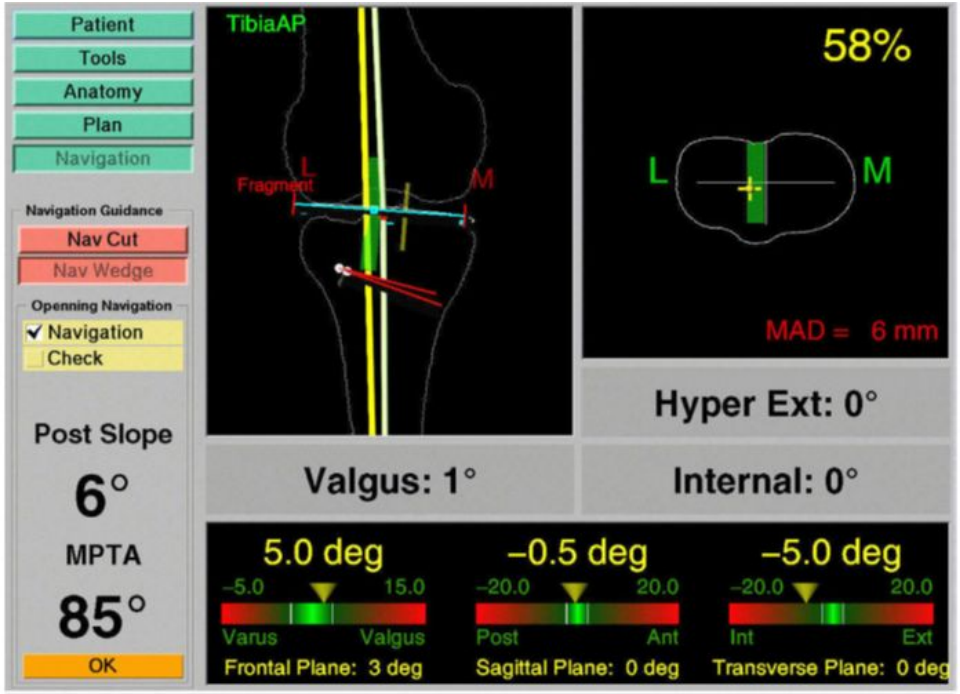


FIGURE 3 | Navigation using surgeon-defined anatomy approach. This virtual model of a patient's knee is generated intra-operatively by digitizing relevant structures. Although a very abstract representation, it provides sufficient information to enable navigated high tibia osteotomy.

State-of-the-Art Research

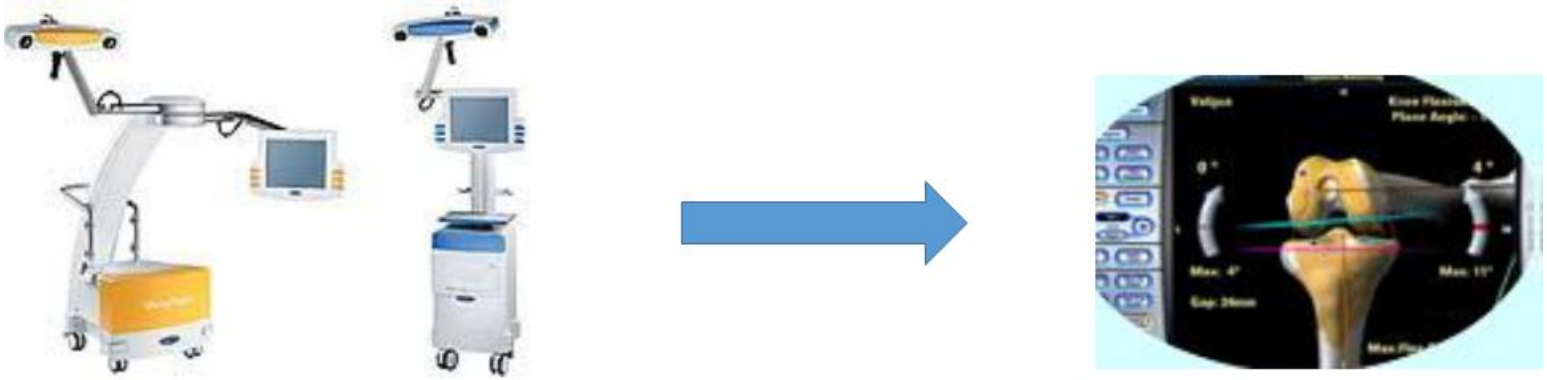


FIGURE 4|TKR Total Knee Replacement using Infrared Sensors

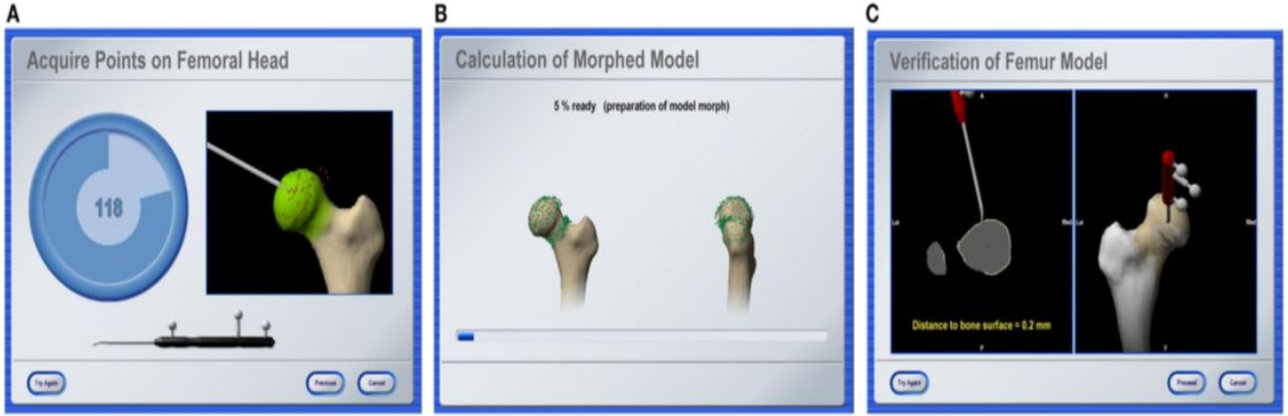


FIGURE 5 | Bone morphing. Screenshots of different stages of an intra-operative bone morphing process. **(A)** Point acquisition; **(B)** calculation of morphed model; and **(C)** verification of final result (Courtesy of BrainLAB AG, Munich, Germany).

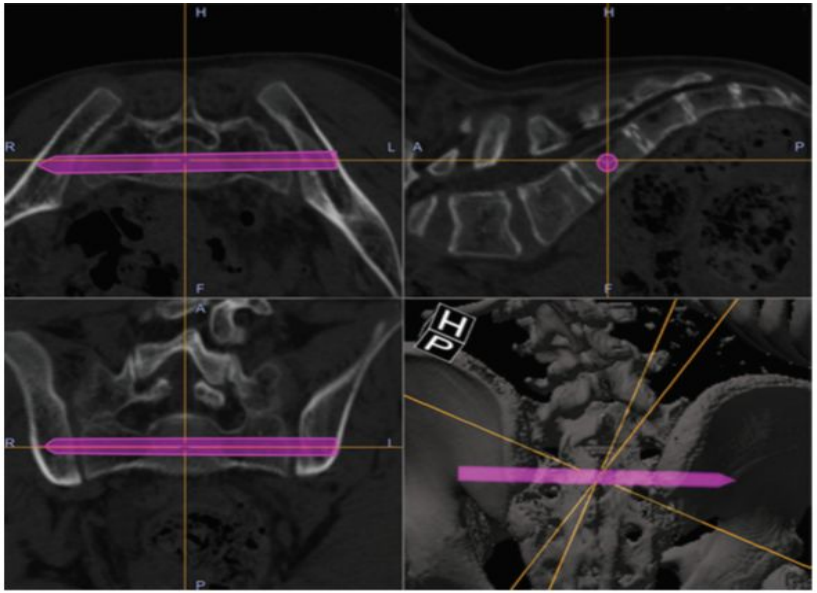
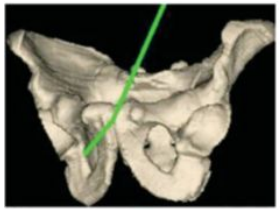
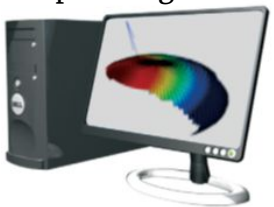


FIGURE 6|Computed tomography–based navigation in tumor surgery in a patient with pathological fracture of the sacrum from metastatic renal cancer. Virtual guidance of sacroiliac screws (A). Axial computed tomography scans before (B) and after (C) computer-assisted sacroiliac screw fixation.



Preoperative planning



Near-real-time analysis

Optotrack camera

Tracking and referencing

Infrared Markers

FIGURE 7 | Architecture of the image-guided navigation system with biomechanical guidance.

Problem Areas

- Operating in Real-time
- Superficial infection at the sites of probes insertion
- Potential increased surgical time required to perform the procedure
- Medical costs to the patient
- Each of the navigation methods has a shortcoming:
  a. CT-based navigation systems increase radiation exposure
  b. Fluoroscopy-based navigation increases the duration of the procedure as the surgeon needs to pause and take images of proper templates
  c. Imageless navigation relies heavily upon the skill of the surgeon to input data from test results

Future Research Areas

- To test the protocol for computer-assisted osteotomy with online biomechanical guidance and to study the reliability of the results when using the BGS.
- To improve the accuracy and better real time and postoperative imaging .
- Improving the accuracy of prosthetic implantation and at furthering efforts at minimizing the surgical exposure in TKR.
- Hybrid CAOS systems are under development
- New generations of mobile-imaging system.

Summary

- Image Guided Surgery plays a pivotal role in Orthopaedics.
- The history of IGS in Orthopaedic Surgery is fairly new.
- Improves the accuracy and precision of various Orthopaedic Surgeries.
- However, the long term operative outcomes have still not been analysed.
- Room for improvement remains in the functionalities and aligning the innovation with the real world in real time.

Any Questions?