SPECT/CT in the painful postoperative knee

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SPECT/CT imaging

- Early: 15min
- Delayed: ~40min

- "transfusion phase"
- "bloodpool – phase" 2 planes
- Whole body ap / pa
- SPECT / CT

[Diagram with images and text boxes]
Whole body ap / pa
SPECT
Low dose CT
“region of interest”
4D-SPECT/CT Protocol

3mm slices femoral head

Modified Imperial CT protocol
(Henckel et al. JBJS Br 2006,
Hirschmann et al. 2011
BMC Medical Imaging)

0.7mm slices knee

3mm slices ankle joint
What information do we need and want?

Mechanical and structural and biological data

- Anatomy
  - Bone
  - Muscles
  - Tendons
  - Ligaments
- Alignment
  - mechanical
  - anatomical
- Biology/Metabolism

The more the better!
What information do we need and want?

3D-CT

• Accurate anatomical localisation and 3D characterisation of anatomy and pathological processes
• Characterisation of bony structure and density
• Determination of anatomical and mechanical axes

Determination of component position in UKR and TKR

<table>
<thead>
<tr>
<th></th>
<th>tibial</th>
<th>femoral</th>
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<tbody>
<tr>
<td>rotation</td>
<td>IR/AR</td>
<td>IR/AR</td>
</tr>
<tr>
<td>sagittal</td>
<td>anterior-posterior Slope</td>
<td>flexion/extension</td>
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<tr>
<td>coronal</td>
<td>varus/valgus</td>
<td>Varus/valgus</td>
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What information do we need and want?

**Determination of component position in 3D-CT:** Much more reliable than 2D-CT or radiographs!

Hirschmann et al. “Comparison of inter-and intra-observer reliability of component position measurements in total knee arthroplasty on conventional radiographs, transverse 2D-CT slices and 3D-CT”; JBJS Br 2011
What information do we need and want?

Combination of SPECT/CT tracer uptake and TKR component position: new era of imaging!

What information do we need and want?

3D volumetric SPECT/CT tracer uptake analysis, localization, quantification and normalization

Hirschmann MT et al., Submitted BMC Medical Imaging 2011
What information do we need and want?

3D volumetric SPECT/CT tracer uptake analysis, localization, quantification and normalization

Hirschmann MT et al., Submitted BMC Medical Imaging 2011
What is the problem?

Partial and total knee arthroplasty shows overall good clinical outcome!

**but:** 20%-40% not satisfied/pain free

**Causes?**
- aseptic loosening
- malposition
- instability
- infection
- patellofemoral OA/hyperpression

Case TKR I

Planar bone scans - perfusion phase, bloodpool phase and delayed phase

male, 86 years, 14 years post TKR left, 3 years post revision TKR right, left knee pain
Case TKR I

99mTc-HDP-SPECT/CT

male, 86 years, 14 years post TKR left, 3 years post revision TKR right, left knee pain
**Case TKR I**

**Diagnosis:** Femoral loosening left knee

**Treatment:** Revision TKR with change of femoral component

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<thead>
<tr>
<th>Rotation</th>
<th>Tibial L</th>
<th>Femoral L</th>
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<tbody>
<tr>
<td>Sagittal</td>
<td>6° post slope</td>
<td>2° Extension</td>
</tr>
<tr>
<td>Coronal</td>
<td>4° varus</td>
<td>8° valgus</td>
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</tbody>
</table>
Case TKR II

Male, 57 years, 2.5 years post UKR and change to TKR, activity related knee pain.
Case TKR II
Planar bone scans - perfusion phase, bloodpool phase and delayed phase

male, 57 years, 2.5 years post UKR and change to TKR, activity related knee pain
Case TKR II

99mTc-HDP-SPECT/CT
Case TKR II

**Diagnosis:** Anterior tibial slope, loosening of the tibial TKR component, no hold between cement and bone

**Treatment:** Revision surgery and change of tibial TKR

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<th>Femoral L</th>
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</thead>
<tbody>
<tr>
<td>Rotation</td>
<td>0°</td>
<td>4° ER</td>
</tr>
<tr>
<td>Sagittal</td>
<td>2° <em>ant slope</em></td>
<td>7° flexion</td>
</tr>
<tr>
<td>Coronal</td>
<td>1° <em>varus</em></td>
<td>6° <em>valgus</em></td>
</tr>
</tbody>
</table>
Case TKR III
Planar bone scans- perfusion phase, bloodpool phase and delayed phase

female, 62 years, 3 years post TKR, right anterior knee pain and left activity related knee pain
Case TKR III
99mTc-HDP-SPECT/CT

female, 62 years, 3 years post TKR, anterior knee pain
Case TKR III

**Diagnosis:** Notching of femoral TKR, patellofemoral OA/hyperpression in primarily non resurfaced patella after TKR right and tricompartmental OA left

**Treatment:** Secondary patellar resurfacing right knee and primary TKR left including resurfacing of patella
Case UKR I

Planar bone scans perfusion, bloodpool and delayed phase

female, 54 years, 1 year post left UKR, left medial knee pain
female, 54 years, 1 year post left UKR, left medial knee pain
Case UKR I

**Diagnosis:** Osteonecrosis below the tibial UKR component

**Treatment:** Biphosphonate treatment for 3 months, if not successful revision surgery to TKR
Case UKR II

Planar bone scans and lateral, ap radiographs of the left knee

female, 54 years, 3 years post left UKR, persistent left medial knee pain
Case UKR II
99mTc-HDP-SPECT/CT
Case UKR II

**Diagnosis:** Impingement of the femoral UKR component at the medial tibial spine, no loosening

**Treatment:** Arthroscopic debridement of the medial notch
Take Home Message!

SPECT/CT in knee arthroplasty

- Better sensitivity and specificity for loosening in painful or unhappy knee arthroplasty
- Combined analysis of component position and tracer uptake
- Tracer uptake depends on component position, type of TKR, UKR, PFJ prosthesis
Take Home Message II!
SPECT/CT in knee arthroplasty

Future research:

• Osseointegrations process

• Novel tracers?

• Software development for easy routine clinical analysis tool allowing combined evaluation of component position and SPECT/CT tracer uptake
SPECT/CT in patients before/after HTO

Mechanical and anatomical alignment correlates well with intensity and distribution pattern of $^{99m}$Tc-HDP-tracer uptake!

Hirschmann MT et al. 2011 submitted Osteoarthritis and Cartilage
SPECT/CT in patients before/after HTO

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Take Home Message I!
SPECT/CT in HTO

• Better understanding of relationship of mechanics and biology

• What makes a patient ‘unhappy’ after HTO?

• How much correction do we need?

• Sensitive and specific follow-up of patients after HTO
Take Home Message II!

SPECT/CT in HTO

• Detecting under- or overcorrection, pseudoarthrosis and degradation problems with biodegradable filling material

• Combined analysis of osteotomy and plate position and tracer uptake

• Combined analysis of mechanical and anatomical axes as well as tracer uptake
Material and methods

MT Hirschmann 2011
Diagnosis: Painful degradation of bioresorbable inference screws after ACL reconstruction, incipient patellofemoral osteoarthritis
Take Home Message I!
SPECT/CT after ACL reconstruction

• Better understanding of relationship of mechanics and biology

• What makes a patient ‘unhappy’ after ACL reconstruction?

• How much tension do we need?

• Sensitive and specific follow-up of patients after ACL reconstruction
• Detecting degradation problems of biodegradable fixation material as well as osseointegration of BTB grafts
• Combined analysis of tunnel position, anatomical/mechanical axes and tracer uptake
• 3D determination of tunnel widening?
Clinically relevant differentiation between a chondral and an osteochondral lesion!
OD 1 year after refixation

OD III complete desintegration - debridment/cartilage repair

Konala P et al., Annals Nuclear Medicine. 2010
Case II cartilage surgery

1 year post medial opening HTO and osteochondral repair using MaioRegen for a osteochondral lesion of the medial femoral condyle in varus aligned knee

**Diagnosis:** Healing of osteochondral repair, calcification and remodelling
Take Home Message!

SPECT/CT in cartilage surgery

• Better understanding of relationship of mechanics and biology

• Sensitive and specific preoperative diagnostics and follow-up of patients after cartilage surgery

• Healing, osseointegration of osteochondral grafts?


Fellowships?

We regularly offer research fellowships to national and international students. The funding of the fellowship has to be organized in advance, either via a research grant or personal funds. Applications including a CV and an application letter should be sent via email to Michael.Hirschmann@unibas.ch.

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