Nuclear Rheumatology?
An initial investigation into use of simple, low-cost detectors for quantification and monitoring of RA disease progression.

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Objective

Use GATE Monte Carlo simulations to show the potential efficacy of simple, low-cost topical detectors for quantification and monitoring of RA disease progression.
Topical Sensor Design

Existing FDA listed uptake probe consisting of a single 3x3x3 mm BGO crystal and silicon photomultiplier.

No shielding or collimation – means omnidirectional detection of localized uptake.

Generates a time-activity curve with 1-second resolution.
Methods

We used an anthropomorphic model of the arm and realistic uptake values\(^2\) for two different radiotracers.

\(^{99}\text{Tc}\)-diphosphonate (\(^{99}\text{Tc}\)-MDP)
\(^{99}\text{Tc}\)-Methotrexate (\(^{99}\text{Tc}\)-MTX)

Methods

All simulations used a nominal injected dose of 10mCi. Specific uptake was modeled as a percentage of injected dose.

<table>
<thead>
<tr>
<th></th>
<th>RA Diagnosis</th>
<th>Healthy</th>
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</thead>
<tbody>
<tr>
<td>99mTc-MDP Synovial</td>
<td>2.00%</td>
<td>0.68%</td>
</tr>
<tr>
<td>99mTc-MDP Background</td>
<td>6.80%</td>
<td>6.80%</td>
</tr>
<tr>
<td>99mTc-MTX Synovial</td>
<td>2.50%</td>
<td>0.03%</td>
</tr>
<tr>
<td>99mTc-MTX Background</td>
<td>3.20%</td>
<td>3.20%</td>
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</tbody>
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Results – Disease State

Difference in simulated detector output between diseased and healthy wrist:

-52.3% for $^{99m}$Tc-MDP
-89.8% for $^{99m}$Tc-MTX

$^{99m}$Tc-MTX is 1.7x more sensitive to disease state.
Results - Placement

Placement can lead to variability in detector output.

We simulated $\pm 15\text{mm}$ variability in detector placement (distal/proximal).

Within $\pm 5\text{mm}$, output error is less than 5%.

May need a detector placement guide for serial human use.
Discussion

Simple topical detectors may be a useful tool to quantify disease state.

Might be possible to improve early diagnosis using baseline uptake measurements.

Treatment response could be tracked using periodic low-dose measurements.
Future Work

Investigate additional target joints, radiotracers and disease stages.

Additional molecular targets – T-cells, leukocytes, antibodies, apoptosis

Longitudinal human studies to follow treatment.
Future Work

Because the detectors provide time-activity curves, could the **kinetics** of tracer uptake be predictive of RA disease progression?
Thank You

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Samantha Lipman, PhD

www.lucernodynamics.com