QUANTIFICATION OF CAROTID PLAQUE PROGRESSION and REGRESSION USING 3D ULTRASOUND IMAGING

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ATHEROSCLEROTIC CAROTID PLAQUE

MONITORING PLAQUE CHANGE IN PATIENTS

• Monitoring plaque change is important in evaluating the effectiveness of different treatment or stroke prevention strategies:
  ➢ Medical Intervention (e.g., statins)
  ➢ Dietary Change (e.g., decreasing LDL, saturated fats, salt, increasing whole grains, vegetables, vitamins, antioxidant)
  ➢ Lifestyle Change (e.g., exercising, quitting smoking, managing stress)

MONITORING CAROTID PLAQUE CHANGES

Developing S/W tools to quantify plaque morphology from 3D US images

• 3D distribution of plaque
• Plaque volume
• Surface characteristics
• Plaque “composition”
3D CAROTID ULTRASOUND

3D Volume Rendering
Internal Carotid Artery Plaque

3D US: Carotid arteries

3D US: Ulcerated carotid plaque
CAROTID PLAQUE: Volume measurement

PROCEDURE: Plaque volume

3D US CAROTID PLAQUES: Segmentation

444 mm$^3$  477 mm$^3$  103 mm$^3$

PLAQUE VOLUME: Variability

• 40 patients
• 37.4 mm$^3$ to 604 mm$^3$
• 5 observers
• 5 measurements/observer/plaque
PLAQUE VOLUME: Variability

MONITORING PLAQUE REGRESSION & PROGRESSION


STATIN THERAPY
Baseline
3 months

STATIN THERAPY: Plaque volume: Baseline & 3 months
CHANGE IN PLAQUE VOLUME:
2.8cm centred on bifurcation

<table>
<thead>
<tr>
<th></th>
<th>Mean $\Delta V$ (mm$^3$)</th>
<th>$\sigma_{AV}$ (mm$^3$)</th>
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</thead>
<tbody>
<tr>
<td>Statin therapy</td>
<td>-90.2*</td>
<td>85</td>
</tr>
<tr>
<td>(n = 17)</td>
<td>(V$_{mean}$ = 690 ± 401 mm$^3$)</td>
<td></td>
</tr>
<tr>
<td>Placebo</td>
<td>16.8*</td>
<td>74</td>
</tr>
<tr>
<td>(n = 21)</td>
<td>(V$_{mean}$ = 722 ± 474 mm$^3$)</td>
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$\sigma_{operator} = 53$ mm$^3$  

*P < 0.0001

MONITORING LOCAL PLAQUE CHANGES


SEGMENTATION OF CAROTID US IMAGES

Champion Technology™ and a Microsoft Video 1 decompressor are needed to see this picture.

SEGMENTED CAROTID IMAGE

3D US image of the CCA wall and lumen
CAROTID WALL BOUNDARY

CAROTID LUMEN BOUNDARY

PLAQUE THICKNESS

- Plaque thickness: Distance between wall and lumen surface
- Display:
  - Mean vessel wall surface
  - Colour-coded plaque thickness map superimposed on mean surface

BASELINE IMAGE

QuickTime™ and a Microsoft Video 1 decompressor are needed to see this picture.
Atorvastatin treatment: Vessel-wall-plus-plaque thickness comparison

VWT Change: Subject 1
**FLATTENING MAP OF 3D VWT**

- Interpretation and comparison of 3D VWT maps are difficult
- The 3D VWT maps require an observer to study them in different angles
- 2D flattened map provides an unobstructed view of 3D VWT distribution
- An unobstructed view is particularly important in assisting the interpretation of a geometrically bifurcating map

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**VWT Change: Subject 2**

Time: 3 months  
Time: 0  
Difference

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**VWT Change: Flattened Map**

Subject 1

Time: 3 months  
Time: 0  
Change

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**VWT Change: Flattened Map**

Subject 2

Time: 3 months  
Time: 0  
Change
3D CAROTID ULTRASOUND: Summary

- Technique and software for analysis and monitoring of carotid plaque:
  - Software for segmentation well characterized
  - Flattened map approach developed
  - Plaque progression/regression trials ongoing
  - New features ongoing (e.g. surface morphology)
  - Many collaborators and users

Thank You

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