Embolization of Intracranial Aneurysms Using Onyx HD 500, Coils and Remodeling Devices

*In vivo and In vitro* Results

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Onyx HD 500

- Material
  - Ethylene vinyl copolymer dissolved in dimethyl sulfoxide (DMSO) opacified with tantalum powder
  - Once contacting ionic solution DMSO dissipates and Onyx hardens into a spongy cohesive material
Onyx Embolization of Sidewall Aneurysm
Prior Experience

- 2004 CAMEO Trial (European study)
  - 97 patients with 100 unruptured aneurysms
  - 12 month evaluation of 71 aneurysms
    - 79% complete occlusion
    - 13% subtotal occlusion
    - 8% incomplete occlusion
  - Acute morbidity/mortality 8%
  - Delayed parent vessel occlusion 12% at 12 months in 75 patients with 3% showing neurologic deficit related to occlusion
  - 22 patients were embolized with balloon mounted stents (17 at primary treatment, 5 at secondary treatment)
  - Mean injection times 95 minutes using 2-3-2 method
Prior Experience

- 2006- Cekirge
  - 100 aneurysms treated with Onyx 500
    - 25 treated with balloon mounted stents
    - Overall recanalization 12.5%
    - 36% recanalization in large lesions
    - 4% recanalization in large lesions embolized with stent
Prior Experience

- 2006- Cekirge
  - 20 patients embolized with Onyx+coils+balloon
  - 1 patient had stent placed
    - Indications
      - Very wide neck
      - Failed balloon test
      - Balloon prolapse into aneurysm
  - 100% occlusion with no recanalization
Embolization Procedure

- Traditional Methodology:  2-3-2
- Modified Methodology
  - Neurophysiology monitoring
  - Catheterize aneurysm with Rebar 14
  - Jail catheter in aneurysm with stent
  - Place deflated balloon across neck
  - Introduce 3D coils to aneurysm
  - Introduce Onyx HD 500
  - Use balloon as needed
Rationale

- Neurophysiology monitoring
  - Allows for prolonged balloon inflations greater than 5 minutes (historical precedent for 20 minute trapping during OR clippings)

- Stent and coils
  - Obviates need for balloon for much or all of procedure
  - Permits faster introduction of Onyx to aneurysm
  - Protects parent vessel from entry into vessel even with balloon deflated
  - Provides for very stable and firm aneurysm cast (concrete + rebar)
Procedural Steps

1

2

3

4

5

6
Three Clinical Cases

Pre

Post
In vitro Evaluation

- Model
  - Pulsatile Flow system with silicone aneurysm models and fresh heparinized bovine blood
  - 9 side wall aneurysms
  - 4 bifurcation aneurysms
  - Flow rate 200-250 ml/minute
  - Pulse rate 40 beats/minute
  - Reynolds number 250 for sidewall; 320 bifurcation (laminar flow)
  - Womersley Number 2.3
Results

- All 13 in vitro aneurysms successfully embolized without distal Onyx embolization
  - 9/13 embolized without balloon inflation
  - 4/4 bifurcation aneurysms embolized without balloon placement.
<table>
<thead>
<tr>
<th>Model (mm)</th>
<th>F:N</th>
<th>An. Vol (mL)</th>
<th>Onyx vol (mL)</th>
<th>Coil Vol (mL)</th>
<th>Balloon Inflat (sec)</th>
<th>Est. 2-3-2 time (min)</th>
<th>Actual time treat (min)</th>
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</thead>
<tbody>
<tr>
<td>1 (7mm)</td>
<td>2</td>
<td>0.18</td>
<td>0.18</td>
<td>0.01</td>
<td>0</td>
<td>14</td>
<td>NA</td>
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<tr>
<td>2 (7mm)</td>
<td>2</td>
<td>0.18</td>
<td>0.16</td>
<td>0.02</td>
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<td>0.18</td>
<td>0.18</td>
<td>0.02</td>
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<tr>
<td>4 (23mm)</td>
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<td>6.10</td>
<td>3.32</td>
<td>0.05</td>
<td>0</td>
<td>142</td>
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<tr>
<td>5 (13mm)</td>
<td>&lt;2</td>
<td>1.10</td>
<td>0.78</td>
<td>0.05</td>
<td>0</td>
<td>38</td>
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<td>6 (13mm)</td>
<td>&lt;2</td>
<td>0.71</td>
<td>0.58</td>
<td>0.04</td>
<td>60</td>
<td>30</td>
<td>6 (-5x)</td>
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<tr>
<td>7 (20mm)</td>
<td>&lt;2</td>
<td>3.10</td>
<td>3.04</td>
<td>0.09</td>
<td>60</td>
<td>134</td>
<td>18 (-7.4x)</td>
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<td>8 (20mm)</td>
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<td>3.10</td>
<td>1.77</td>
<td>0.09</td>
<td>60</td>
<td>78</td>
<td>30 (-2.6x)</td>
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<tr>
<td>9 (10mm)</td>
<td>&lt;2</td>
<td>0.93</td>
<td>0.78</td>
<td>0.04</td>
<td>60 (x2)</td>
<td>32</td>
<td>29</td>
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<tr>
<td>10 (7mm)</td>
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<td>0.27</td>
<td>0.13</td>
<td>0.03</td>
<td>0</td>
<td>14</td>
<td>NA</td>
</tr>
<tr>
<td>11 (7MM)</td>
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<td>0.33</td>
<td>0.04</td>
<td>0</td>
<td>22</td>
<td>*8 (-2.8x)</td>
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<td>0.23</td>
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<td>0.20</td>
<td>0.04</td>
<td>0</td>
<td>22</td>
<td>*3 (-7.3x)</td>
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</table>
Sample Side Wall Aneurysm
Sample 7 mm Bifurcation Aneurysm (2 minute injection)
Contact Angle Data

- Contact angle is the angle that the edge of an ideal drop makes with a flat surface.
- The lower the contact angle the greater the attraction between the surface and the liquid.
- CA measures a liquid’s affinity for a solid and quantifies the degree of a liquid drop’s spread when placed on the solid.
  - Examples
    - Water spreads almost completely on glass with a contact angle near 0 degrees
    - Mercury beads up on glass and spreads very little. High contact angle.
Contact Angle Data

- Contact angle $< 90$ degrees is considered mostly wetting (high affinity)
- CA data shows that where it makes contact Onyx wants to flow along coils and remodeling devices used in this study
  - Onyx-Nitinol CA 69.5 degrees
  - Onyx-Platinum/Tungsten CA 70.9%
Study Findings and Directions

- Onyx embolization of aneurysms using coils and remodeling devices is possible in vitro and in vivo.
- Onyx embolization of side wall aneurysms when performed in conjunction with coils and stents may not require balloon inflation or may only require minimal inflation times near the procedure’s conclusion.
- Onyx embolization of bifurcation aneurysms is potentially possible without the use of balloons when coils and stents are utilized.
- Onyx embolization with coils and stents allows for more rapid introduction of liquid polymer.
- Onyx has an affinity for nitinol-tungsten and platinum.
Questions

- Does combination of Onyx with coils and remodeling devices reduce the incidence of recanalization?
- Does use of Onyx with coils and remodeling devices make the procedure safer?
- How does Onyx behave with bioactive coils?
- Do coils and stents reduce chance of embolizing nearby branch vessels?