Gas Formation and its Effect after Implantation of Bioabsorbable Metal Magnesium

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Disclosure

NO CONFLICT TO DISCLOSE
Gas Formation and its Effect after Implantation of Bioabsorbable Metal Magnesium
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We have no potential conflicts with this presentation.
Introduction

- Metallic biomaterials (stainless steel and titanium)
  - most commonly used for osteotomy and fusion surgery in foot and ankle
  - physical and psychological burden to the patients owing to the second surgery (hardware removal)

- Bioabsorbable polymer
  - mechanically weak strength and osteolysis
  - magnesium (Mg) implant: gas formation by the biodegradation of magnesium alloys[1,2]
Purpose

• To identify the characteristics of gas formation and histological reaction during the absorption of Mg on surrounding tissue using in vitro and in vivo rodent model
Material and Methods

- In vitro immersion test
  - Immerged in EBSS (Earle’s balanced salt solution) at pH=7.4, kept at 37°C
  - Gas value was detected every 24 hr for 30 days
Material and Methods

• In vivo immersion test
  – 24 male Sprague Dawley rats (back muscle) (SD, 250-270 g, 7 weeks)
  – Two groups
    • Experimental group (n=18): implantation in the rat’s back
    • Control group (n=6): non-implantation group.
Results

- In vitro immersion test – gas component analysis

<table>
<thead>
<tr>
<th>Immersed day</th>
<th>FID : Height (μV)</th>
<th>TCD : Height (pA)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>H₂</td>
<td>CO</td>
</tr>
<tr>
<td>5</td>
<td>2.483 ×10⁴± 0.028</td>
<td>93.428±0.14</td>
</tr>
<tr>
<td>10</td>
<td>2.438 ×10⁴± 0.041</td>
<td>92.743±0.54</td>
</tr>
<tr>
<td>15</td>
<td>2.427×10⁴± 0.125</td>
<td>109.59±0.68</td>
</tr>
<tr>
<td>20</td>
<td>2.295×10⁴± 0.075</td>
<td>96.53±0.18</td>
</tr>
<tr>
<td>25</td>
<td>2.425×10⁴± 0.117</td>
<td>74.31±0.98</td>
</tr>
<tr>
<td>30</td>
<td>2.279×10⁴± 0.096</td>
<td>80.95±0.35</td>
</tr>
</tbody>
</table>

Fig.1. Gas component analysis of magnesium during immersed in EBSS by (a) FID and (b) TCD. Gas is mainly composed of H₂ (2.483 ×10⁴± 0.028 μV), but a small amount of CO was detected in in vitro immersion test.
In vivo immersion test – gas formation

Fig.2. Micro CT images (A), gas formation and sample volume of implantation to rats for 30 days (B)
Gas volume shows significantly higher at 5 days (0.084 ml) than other times (0.005 ml for 30 days) after implantation, and is gradually decreased over time.
• Surface morphology in vitro and in vivo

(A) In vitro test

(B) In vivo test

Fig. 3. SEM images of Mg surface and EDX spectrums in vitro(A) and in vivo(B). They show a lot of cracks and the formation of apatite particles on Mg plate.
• Histological examination

![Histological examination](image)

Fig. 4. Histological examination in adjacent tissue (A) (*: bubble jacket) and kidney & liver (B). Nuclei gathered densely around the small and multiple air bubble pockets at 5 days and the number of gas bubbles and their volumes were reduced over time in tissue surrounded implant, and there is no difference in kidney and liver tissue between implant and sham surgery.
Conclusion

• The immersion of Mg in EBSS generated H₂ as the major forming gas, and CO and CO₂

• The in vivo implantation of Mg into rats’ back muscle generated gas pockets inside the tissues because the initial gas formation rate was faster than the gas-absorbing rate; however, gas volume decreased after 15 days as the gas formation and absorbing rates became similar

• The amount of Mg ions inside the liver and kidneys changed as well, but it was within a normal range, such that inflammation and tissue deformation were not found.
References