Reducing temperature elevation of bone drilling

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Hearing Loss or Impairment

Minimally Invasive Robotic Cochlear Implantation

+ reduces hospitalization time
+ saves costs
- Additional risks
  ➢ Thermal nerve damage

Materials

- Reducing the temperature elevation of the drilling process
  - Drill bit design
  - Process parameters
    - Custom made single flute helical drill bit
    - Interval drilling
  - Irrigation

Design of experiments:

<table>
<thead>
<tr>
<th>Interval</th>
<th>Irrigation 0 ml/min</th>
<th>15 ml/min</th>
<th>30 ml/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 mm</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>1 mm</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2 mm</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Methods

- Measuring of temperature elevation during the drilling process without difficult placement of thermocouples
- New drill bit design has a significant lower torque and thrust force compared to the standard drill bit (due to higher rake angle)

Results

The results show that irrigation has a major effect on temperature reduction, where the effect of flute clearing is more important than actual cooling. Due to the low thermal conductivity of bone, drilling in intervals is in general beneficial for limiting the accumulation of heat and allowing the bone to cool down in-between intervals while improving chip evacuation as well as flute cleaning when the drill bit is extracted. Flute clogging with bone chips has been found to be the reason for the above-average peaks of temperatures, forces and torques which leads to excessive temperature rise.

Probability of thermal damage

Discuss:ion and Outlook

- The combination of high irrigation rate (30 ml/min, 18 gauge needle) and small continuously drilled interval (0.5 mm) prevents flute clogging and limits the accumulation of heat within the bone
- The temperature elevation can be kept below critical thermal threshold when this parameter combination is used with the new drill bit design
  ➢ Drilling process can be further optimized by using a previously introduced thermal model which uses the torque and force signal to predict the temperature elevation of the drilling process in real-time

Reference:

Lee, An experimental investigation of thermal exposure during bone drilling, Medical Engineering & Physics, 34 (10): 2012