A Comparison of Histopathologic Margin Assessment after Steel Scalpel, Monopolar Electrosurgery, and Ultrasonic Scalpel Glossectomy in a Rat Model

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ABSTRACT

Energy based devices are used in glossectomy to achieve hemostasis and improve operative efficiency. However, there is clearly a tradeoff associated with these devices with respect to distortion of tissues at the surgical margin when compared to the cold steel technique. Monopolar electrosurgery uses alternating electrical current leading to heating of tissue, which results in disruption by either boiling or coagulation. This heat-based mechanism of action is responsible for the comparatively large zone of tissue injury adjacent to the surgical incision.

Ultrasonic scalpel uses mechanical energy in the form of a vibrating blade to denature proteins by disrupting tertiary hydrogen bonds. It accomplishes cutting and coagulation of tissues at comparatively lower temperatures.

Previous studies have suggested that the ultrasonic scalpel causes less tissue damage adjacent to the surgical margin. Our study suggests that when compared to monopolar electrosurgery, the ultrasonic scalpel causes qualitatively less tissue distortion at the surgical margin with respect to factors that may influence accurate histopathologic assessment.

To determine the clinical relevance of these findings, further study of human specimens with tumor at the surgical margin will be required.

DISCUSSION

Educational Objective:

• Energy based devices are used in glossectomy to achieve hemostasis and improve operative efficiency. However, there is clearly a tradeoff associated with these devices with respect to distortion of tissues at the surgical margin when compared to the cold steel technique. Monopolar electrosurgery uses alternating electrical current leading to heating of tissue, which results in disruption by either boiling or coagulation. This heat-based mechanism of action is responsible for the comparatively large zone of tissue injury adjacent to the surgical incision.

• Ultrasonic scalpel uses mechanical energy in the form of a vibrating blade to denature proteins by disrupting tertiary hydrogen bonds. It accomplishes cutting and coagulation of tissues at comparatively lower temperatures.

• Previous studies have suggested that the ultrasonic scalpel causes less tissue damage adjacent to the surgical margin. Our study suggests that when compared to monopolar electrosurgery, the ultrasonic scalpel causes qualitatively less tissue distortion at the surgical margin with respect to factors that may influence accurate histopathologic assessment.

To determine the clinical relevance of these findings, further study of human specimens with tumor at the surgical margin will be required.

RESULTS

Table 1: Comparison of Surgical Techniques with Respect to Tissue Margin Distortion

<table>
<thead>
<tr>
<th>Distortion Subtype</th>
<th>Steel Scalpel</th>
<th>Ultrasonic Scalpel</th>
<th>Monopolar Electrosurgery</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Margin Fragmentation</td>
<td>.77</td>
<td>1.03</td>
<td>1.77</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Crush/cautery artifact</td>
<td>.33</td>
<td>1.57</td>
<td>1.80</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Extravascular blood</td>
<td>.13</td>
<td>1.27</td>
<td>1.63</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Capillary Congestion</td>
<td>.75</td>
<td>.70</td>
<td>1.27</td>
<td>P=0.0036</td>
</tr>
<tr>
<td>Artifact Depth (millimeters)</td>
<td>&lt;.01</td>
<td>.26</td>
<td>.33</td>
<td>P&lt;0.001</td>
</tr>
</tbody>
</table>

*Score: 0—0%, 1—1% to 25%, 2—26% to 50% and 3—greater than 50% of margin.

• Paired t-tests revealed significant differences between steel scalpel and ultrasonic scalpel and between steel scalpel and monopolar electrosurgery, but not between ultrasonic scalpel and monopolar electrosurgery.

HISTOPATHOLOGY

Figure 1. Steel scalpel specimen demonstrating smooth cut margin (arrow) with no cautery artifact. (H&E, 10x)

Figure 2. Monopolar electrosurgery specimen demonstrating margin fragmentation and prominent cautery artifact (arrow) with cellular shrinkage and nuclear streaking. (H&E, 10x)

Figure 3. Ultrasonic scalpel specimen demonstrating relatively smooth margin and mild cautery artifact (arrow) (H&E, 5x)

METHODS

Animals: Thirty adult male Sprague-Dawley rats, weighing 350-400 g, made up the study population.

Surgical Procedures:

• Steel scalpel: Bard-Parker No. 15 stainless steel blade on a number 7 knife handle (BD, Franklin Lakes, NJ)
• Monopolar electrosurgical device: Force FX monopolar electrosurgical generator with handswitching pencil (E2515) and needle electrode (E1552) (Valleylab, Boulder, CO)
• Ultrasonic scalpel: Harmonic Scalpel with the Harmonic Focus handpiece (Ethicon Endosurgery, Cincinnati, OH).

Surgical Procedures:

• Steel scalpel: incision carried down through the mucosa and muscle to complete the excision of the anterior 1 cm of the tongue.
• Monopolar electrosurgery: coagulation current of the device was used at a power level of 30 W to complete the excision.
• Ultrasonic scalpel: the tongue was grasped at the mucosal incision line between the curved shears of the handpiece and the MIN control was activated at a power level of 3 until the specimen was removed.

Histopathologic Comparison:

• Hematoxylin and eosin (H&E) slides were reviewed by a Head and Neck pathologist (W.C.F.) blinded to the surgical procedure
• A grading scale developed for a study of tissue margin distortion in renal cancer was modified for use in glossectomy and then employed to quantify differences in margin distortion between the different surgical techniques.[12]
• The subtypes of margin distortion evaluated were margin fragmentation, cautery/crush artifact, extravascular blood clot at the cut margin, capillary congestion, and artifact depth.
• Three adjacent 10x fields were examined to quantify the presence of each subtype as a percentage of the total inked cut margin. The grading scale used was as follows: 0—none at margin, 1—1%-25%, 2—26%-50%, and greater than 50%.

Statistical Analysis: one-way analysis of variance (ANOVA) was performed; paired t-tests were then used to compare surgical techniques against each other with statistical significance set at p<0.05.

REFERENCES