Radiofrequency:
New Targets/Techniques: Shoulder, Knee, Hip, Spine

Maxim S. Eckmann, M.D.
Professor of Anesthesiology and Pain Medicine
President Elect, Texas Pain Society
UT Health San Antonio, Texas, USA
## Faculty Disclosure

<table>
<thead>
<tr>
<th>Category</th>
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<td>Honoraria/Expenses</td>
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<td>Employee</td>
<td>UT Health San Antonio</td>
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Nothing to disclose

Yes, as follows: X

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## Off-Label Product Use

Will you be presenting or referencing off-label or investigational use of a therapeutic product?

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No X
Objectives

• Evaluate available quantitative neuroanatomy of the shoulder, knee, hip, and spine.

• Apply technical options and known techniques to treat chronic pain of these regions.

• Appraise knowledge gaps in the treatment of chronic pain using radiofrequency ablation.
Science of Radiofrequency Ablation (RFA)
Conventional “Standard” Radiofrequency Ablation (SRFA)

Tissue Temperature vs. Distance from Electrode

Virtual Tip Temperature

Permanent Lesion

Zone of Reversibility

Body Temperature

Distance from Electrode Tip (arbitrary units)

Small Lesion

Large Lesion

Cosman ER. Neurosurgery 1984;15(6): 945-950
Ahadian FM. Current Pain and Headache Reports 2004;8:34-40
Lesion Size Estimation (SRFA)

<table>
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<tr>
<th></th>
<th>SMK</th>
<th>RRE</th>
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<tr>
<td>w</td>
<td>0.7mm</td>
<td>1.6 mm</td>
</tr>
<tr>
<td>r</td>
<td>2.3 (w) +/- 0.4</td>
<td>1.6 (w) +/- 0.3</td>
</tr>
<tr>
<td>d</td>
<td>1.4 (w)</td>
<td>0.4 (w)</td>
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</tbody>
</table>

97.5% confident of coagulating tissues within 1.0-1.7 electrode widths radially from probe.

**Needle Gauge** | **Lesion Diameter (mm)**
---|---
18 | 3.8-5.6
20 | 2.7-4.0
21 | 2.5-3.6

More is Better? Augmentation and the Quest for Larger Lesions

- Larger Gauge, Longer Active Tip
- Ionic Fluid Pre-Injection
- Palisading Monopolar Lesions
- Bipolar Lesions, Palisading Bipolar
- Cooled RFA
- Multi-tined RFA
- Multipolar RFA
Tissue Factors Affecting Lesions

- Fluid Pre-injection and time to 180 sec
- Bone Proximity


Example: Multi-tined Probes

- Monopolar Conventional RFA
- Functionally Larger Active Tip

Multipolar Probes
Cooled (not COLD) Radiofrequency Ablation (CRFA)
Cooled-Tip Ablation Results in Increased Radiofrequency Power Delivery and Lesion Size in the Canine Heart: Importance of Catheter-Tip Temperature Monitoring for Prevention of Popping and Impedance Rise

Ichiro Watanabe, Riko Masuki, Nuo Min, Naohiro Oshikawa, Kinya Okubo, Hidezou Sugimura, Toshikazu Kojima, Satoshi Saito, Yukio Ozawa, and Katsuo Kamitsuru

Optimal
Excessive Current
Rapid Heating
Low Current
Cooled RF

• Cooled RF now applied to spine ablation
  • Has been used elsewhere for increasing size of solid organ lesions to 30-50mm.
• Applied to joint denervation for pain management.
• Fluid Pre-injection may not affect lesion size

Bipolar Cooled RFA

- Large Strip Lesions
- Diminishing returns >24 mm

Clinical Applications of Cooled RFA

• Disc Biacuplasty
  • Best quality evidence among Thermal/RF disc ablation

• Lateral Branch Ablation (SI joint)
  • Superior results to conventional

• Spine and Major Joints
  • Potentially better efficacy, more data emerging

• Spine Tumors and Intravertebral Ablation
Complications summary, published and verbal reports

- Thoracic CRFA
  - Skin Burn

- Genicular CRFA
  - Hematoma
  - Skin Burn

- Hip Articular CRFA
  - Femoral Artery Cannulation / Hematoma
  - Femoral Nerve Injury


Shoulder Nerve Ablation (New Targets)
Suprascapular Nerve (SN) – Posterior View

Legend: SS - Supraspinatus; IS - Infraspinatus; SGN – Spinoglenoid Notch; M – Medial; L - Lateral

Suprascapular Nerve – Medial and Lateral Trunks – Superior View

(Reproduced with Permission from Dr. Philip Peng, RAPM 2018)
Tran, John, University of Toronto, Surgery (Division of Anatomy);
Peng, Philip, Toronto Western Hospital, University Health Network, Anesthesia;
Agur, Anne, University of Toronto, Surgery (Division of Anatomy)
Axillary Nerve (AN) – Posterior View

Legend: DM – Deltoid Muscle; HH – Humeral Head; M – Medial; L - Lateral

Quantitative analysis of the distal, lateral, and posterior articular branches of the axillary nerve to the shoulder: implications for intervention

Brittany Bickelhaupt, Maxim S Eckmann, Caroline Brennick, Omid B Rahimi
Lateral Pectoral Nerve (LPN) – Anterior View

Legend: CL - Clavicle; HH – Humeral Head; CP – Coracoid Process; M – Medial; L - Lateral

Thermal Radiofrequency Ablation of the Articular Branch of the Lateral Pectoral Nerve: A Case Report and Novel Technique

Maxim S. Eckmann, MD,* Bryan K. Lai, MD,* Marco A. Uribe III, MD,† Samir Patel, DO,* and Jonathan A. Benfield, DO‡
Summary and Quantitative Frequency Mapping

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sp</th>
<th>Suprascapular nerve</th>
<th>Lateral pectoral nerve</th>
<th>Axillary nerve</th>
<th>Nerves to subscapularis</th>
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<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
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<td>x NI</td>
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<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
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<td>NI 2/125</td>
<td>NI 8/45</td>
<td>NI 49/45 (Pir) NI</td>
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<td>NI NI</td>
<td>NI 16/20</td>
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<td>12</td>
<td>NI 12/12</td>
<td>NI NI</td>
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<td>Navu et al. (2015)</td>
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<td>NI 29/43</td>
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<td>Nam et al. (2016)</td>
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<tr>
<td>Eickmann et al. (2017)</td>
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<td>16/16 NS</td>
<td>12/14</td>
<td>16/16</td>
<td>NS NS NS NS</td>
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Shoulder Nerve Ablation – Emerging Knowledge

- Chronic shoulder pain may stem from a variety of causes including rotator cuff disease, glenohumeral joint (GHJ) osteoarthritis, nerve injuries, and capsulitis.
- The suprascapular, axillary, lateral pectoral, and subscapular nerves are known to innervate the GHJ.
- Other nerves may also contribute theoretically by Hilton’s Law of joint innervation.
- Articular branch nerves have been described and may be future clinical targets.
- Case series exist of main suprascapular nerve ablation to palliate shoulder pain in patients with limited functional use of the shoulder (Simopoulos 2012).
  - Patients can retain or improve function due to reduced pain and compensation.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Pre-treatment NRS score</th>
<th>Post-treatment NRS score (at 5–7 weeks)</th>
<th>Pre-treatment ROM [F/A]</th>
<th>Post-treatment ROM [F/A]</th>
<th>Duration of relief (months)</th>
<th>Repeat procedures (n)</th>
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<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>2</td>
<td>60°/60° (P)</td>
<td>90°/90° (P)</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>4</td>
<td>60°/50° (P)</td>
<td>80°/80° (P)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>2</td>
<td>20°/20° (P)</td>
<td>45°/90° (P)</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>3</td>
<td>90°/90° (A)</td>
<td>120°/120° (A)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>3</td>
<td>90°/90° (A)</td>
<td>180°/180° (A)</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>4</td>
<td>40°/40° (A)</td>
<td>80°/80° (A)</td>
<td>6</td>
<td>2</td>
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</table>

Abbreviations: A, active; F/A, flexion and abduction; NRS, numeric rating scale; P, passive.

Locations With Full Motor Sparing Potential
• 6/10 (60% [CI 29.7%-90.4%]) CRFA patients were responders, >50% pain relief of 6.6 [CI 4.6-8.6] mo

• 3/9 (33% [CI 2.3%-63.4%]) TRFA were responders, >50% pain relief for 5.3 [CI 0.9-9.7] mo

• Three CRFA responders and one TRFA responder still had significant pain relief at conclusion of retrospective review

• Shoulder osteoarthritis was the most common primary diagnosis in patients receiving RFA (11/19, 57.9% [CI 35.7%-80.1%]).
Suprascapular Branch Targeting (Posterior)
Axillary Branch Targeting (Posterior)
Lateral Pectoral Nerve Branch Targeting (Anterior)
<table>
<thead>
<tr>
<th>Subject number</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Weight (kg)</th>
<th>Primary diagnosis</th>
<th>Duration of Shoulder Pain</th>
<th>Procedure</th>
<th>Nerves involved</th>
<th>Relief Duration (Month)</th>
<th>Percent relief</th>
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<tr>
<td>Responders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1(^o)</td>
<td>64</td>
<td>M</td>
<td>136.1</td>
<td>Painful Rotator cuff tendinopathy</td>
<td>&gt;6 months</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>3</td>
<td>80%</td>
</tr>
<tr>
<td>2(^o)</td>
<td>70</td>
<td>M</td>
<td>61.2</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>3</td>
<td>60%</td>
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<tr>
<td>3(^o)</td>
<td>90</td>
<td>M</td>
<td>61.2</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>TRFA</td>
<td>abLPN</td>
<td>10</td>
<td>&gt;50%</td>
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<td>4(^o)</td>
<td>85</td>
<td>M</td>
<td>108.9</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>CRFA</td>
<td>abAN, abSN</td>
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<td>100%</td>
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<tr>
<td>5</td>
<td>77</td>
<td>Unk</td>
<td></td>
<td>Painful Rotator cuff tendinopathy</td>
<td>&gt;1 year</td>
<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
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<td>70%</td>
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<tr>
<td>6(^o)</td>
<td>89</td>
<td>F</td>
<td>72.9</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
<td>5</td>
<td>&gt;50%</td>
</tr>
<tr>
<td>7(^o)</td>
<td>66</td>
<td>F</td>
<td>103.4</td>
<td>Painful Rotator cuff tendinopathy</td>
<td>&gt;6 months</td>
<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
<td>9</td>
<td>100%</td>
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<tr>
<td>8(^o)</td>
<td>71</td>
<td>F</td>
<td>81.7</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
<td>4</td>
<td>50%</td>
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<tr>
<td>9(^o)</td>
<td>57</td>
<td>F</td>
<td>72.9</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
<td>8</td>
<td>80%</td>
</tr>
<tr>
<td>Subject number</td>
<td>Age (yrs)</td>
<td>Sex</td>
<td>Weight (kg)</td>
<td>Primary diagnosis</td>
<td>Duration of Shoulder Pain</td>
<td>Procedure</td>
<td>Nerves Involved</td>
<td>Follow-up Duration (Months)</td>
<td>Percent relief</td>
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<td>Non-Responders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>10</td>
<td>85</td>
<td>F</td>
<td>55.3</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>3</td>
<td>0%</td>
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<tr>
<td>11(^o)</td>
<td>53</td>
<td>F</td>
<td>98.9</td>
<td>Complex regional pain syndrome, type 1</td>
<td>4 years</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>1</td>
<td>30%</td>
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<tr>
<td>12(^o)</td>
<td>47</td>
<td>F</td>
<td>81.6</td>
<td>Adhesive capsulitis of both shoulders</td>
<td>&gt;1 year</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>4</td>
<td>0%</td>
</tr>
<tr>
<td>13(^o)</td>
<td>47</td>
<td>F</td>
<td>81.6</td>
<td>Adhesive capsulitis of both shoulders</td>
<td>&gt;1 year</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>3</td>
<td>0%</td>
</tr>
<tr>
<td>14</td>
<td>61</td>
<td>M</td>
<td>109.3</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>3</td>
<td>0%</td>
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<tr>
<td>15</td>
<td>75</td>
<td>F</td>
<td>76</td>
<td>Osteoarthritis of the shoulder</td>
<td>&gt;6 months</td>
<td>TRFA</td>
<td>abAN, abSN, abLPN</td>
<td>2</td>
<td>40%</td>
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<tr>
<td>16(^o)</td>
<td>52</td>
<td>F</td>
<td>127</td>
<td>Sprengel deformity</td>
<td>3 years</td>
<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
<td>2</td>
<td>20%</td>
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<tr>
<td>17</td>
<td>63</td>
<td>F</td>
<td>79.4</td>
<td>Osteoarthritis of the shoulder</td>
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<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
<td>1</td>
<td>0%</td>
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<tr>
<td>18(^o)</td>
<td>88</td>
<td>M</td>
<td></td>
<td>Osteoarthritis of the shoulder</td>
<td>4 years</td>
<td>CRFA</td>
<td>abAN, abSN, abLPN</td>
<td>1</td>
<td>10%</td>
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<tr>
<td>19(^o)</td>
<td>34</td>
<td>M</td>
<td>83.9</td>
<td>Painful Rotator cuff tendinopathy</td>
<td>3 years</td>
<td>CRFA</td>
<td>abSN</td>
<td>10</td>
<td>0%</td>
</tr>
</tbody>
</table>

*More than one ablative procedure; \(\dagger\)On going relief at time of last follow-up; \(\dagger\)Less than 3 terminal nerve branches were ablated; 0History of shoulder surgery; ▪History of arthroplasty surgery

TRFA= Traditional radiofrequency ablation; CRFA= Cooled radiofrequency ablation; abAN=Axillary nerve; abSN=Suprascapular nerve; abLPN=Lateral pectoral nerve; Unk= Unknown
Nerve to Subscapularis innervates the Anterior-Superior GHJ

Tran, John, University of Toronto, Surgery (Division of Anatomy);
Peng, Philip, Toronto Western Hospital, University Health Network, Anesthesia;
Agur, Anne, University of Toronto, Surgery (Division of Anatomy)
Ablation associated injuries

Percutaneous Cryoablation of Scapular Metastasis Associated with Iatrogenic Injury to the Suprascapular, Subscapular, and Axillary Nerves

From: Patrick L. Adams, BS
Alda L. Tam, MD
Behrang Amini, MD
Quoc B. Hoang, MD
Valerae O. Lewis, MD
Steven Y. Huang, MD
School of Medicine (P.L.A.)
Baylor College of Medicine
Houston, Texas
Departments of Diagnostic Radiology (B.A.)
Orthopedic Oncology (V.O.L.) and
Interventional Radiology (A.L.T., S.Y.H.)
The University of Texas MD Anderson Cancer Center

MRI, 2 months after lesion
Shoulder Nerve Ablation – Summary

• The shoulder is a complex major joint with emerging neuroanatomic understanding

• Chronic shoulder pain may include: rotator cuff disease, osteoarthritis of the glenohumeral joint (GHJ), nerve injuries, capsulitis, and others.

• The suprascapular, axillary, lateral pectoral, subscapular nerves, are known to innervate the GHJ$^{1,2,3}$. (and possibly others)

• Articular branch nerves have been described and may be future clinical targets$^{1,2,4,5}$.

• Case series exist of main suprascapular nerve ablation to palliate shoulder pain in patients with limited functional use of the shoulder$^4$.
  
  • While weakness of the shoulder is a logical complication, compensation possible.

• Case series of articular shoulder ablation shows promise in patients with OA$^5$. 

Genicular Nerve Ablation for Chronic Knee Pain (Latest Anatomy)
Anatomical Study of the Innervation of Anterior Knee Joint Capsule
Implication for Image-Guided Intervention

John Tran, HBSc, * Philip W.H. Peng, MBBS, † Karen Lam, MD, ‡ Ehtesham Baig, MD, ‡ Anne M.R. Agur, PhD,* and Michael Gofeld, MD†

Response:
Genicular Conventional RFA

Genicular Conventional RFA

Percutaneous Radiofrequency Treatment for Refractory Anteromedial Pain of Osteoarthritic Knees

Masahiko Ikeuchi, MD, PhD,* Takahiro Ushida, MD, PhD,** Masashi Izumi, MD,* and Toshikazu Tani, MD, PhD*
Emerging Data for Genicular Cooled RFA

Cooled Radiofrequency Ablation of the Genicular Nerves for Chronic Pain due to Knee Osteoarthritis: Six-Month Outcomes

Zachary L. McCormick, MD, Marc Korn, MD, Rajiv Reddy, MD, Austin Marcolina, BS, David Deyo, MD, MS, MHA, Ryan Mittle, MD, Daniel Cushman, MD, Meghan Bhave, MD, Robert J. McCarthy, PharmD, Dost Khan, MD, Geets Nagpal, MD, and David R. Walega, MD

Setting. Academic pain medicine center.

Subjects. Consecutive patients with knee OA and 50% or greater pain relief following genicular nerve blocks who underwent genicular nerve C-RFA.

<table>
<thead>
<tr>
<th>Number of Patients (N = 33)</th>
<th>Number of Treated Knees (N = 52)</th>
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<tbody>
<tr>
<td>Age, y</td>
<td>66 (32–77)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>10 (30)</td>
</tr>
<tr>
<td>Female</td>
<td>23 (70)</td>
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<td>Body mass index, kg/m²</td>
<td>31 (24–38)</td>
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<td>Duration of pain at</td>
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<tr>
<td>≤2</td>
<td>10 (19)</td>
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<td>&gt;2–≥5</td>
<td>24 (46)</td>
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<td>&gt;5</td>
<td>18 (35)</td>
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<td>Smoker</td>
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<td>&gt;3 alcoholic drinks/d</td>
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<tr>
<td>History of arthroscopic</td>
<td></td>
</tr>
<tr>
<td>surgery in symptomatic knee*</td>
<td>13 (25)</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
</tr>
<tr>
<td>Married/partnered</td>
<td>19 (58)</td>
</tr>
<tr>
<td>Single/widowed</td>
<td>14 (42)</td>
</tr>
<tr>
<td>Numeric rating score for</td>
<td></td>
</tr>
<tr>
<td>pain (0–10)*</td>
<td>8 (7–9)</td>
</tr>
<tr>
<td>Medication Quantification</td>
<td></td>
</tr>
<tr>
<td>Scale III score</td>
<td>6 (3–8)</td>
</tr>
<tr>
<td>Percent pain relief from</td>
<td></td>
</tr>
<tr>
<td>diagnostic blocks*</td>
<td></td>
</tr>
<tr>
<td>50–79%</td>
<td>12 (23)</td>
</tr>
<tr>
<td>80–99%</td>
<td>6 (12)</td>
</tr>
<tr>
<td>100%</td>
<td>34 (65)</td>
</tr>
<tr>
<td>Bilateral procedures</td>
<td>19 (57)</td>
</tr>
<tr>
<td>Duration between procedure</td>
<td></td>
</tr>
<tr>
<td>and follow-up,* mio</td>
<td>8 (6–10)</td>
</tr>
</tbody>
</table>
Emerging Data for Genicular Cooled RFA

Table 5  Logistic regression model for clinical success† following genicular nerve block

<table>
<thead>
<tr>
<th></th>
<th>β</th>
<th>P</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index, kg/m²</td>
<td>0.16</td>
<td>0.025</td>
<td>1.17</td>
<td>1.02–1.35</td>
</tr>
<tr>
<td>Duration of pain at presentation, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;5</td>
<td>2.39</td>
<td>0.046</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>&gt;2–&lt;5</td>
<td>4.35</td>
<td>0.007</td>
<td>10.54</td>
<td>0.67–168</td>
</tr>
<tr>
<td>≤2</td>
<td></td>
<td></td>
<td>13.05</td>
<td>1.30–131</td>
</tr>
<tr>
<td>Percent pain relief from diagnostic blocks*</td>
<td></td>
<td>0.071</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50–79%</td>
<td>2.35</td>
<td>0.096</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>80–99%</td>
<td>2.57</td>
<td>0.029</td>
<td>10.91</td>
<td>1.04–115</td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td></td>
<td>77.34</td>
<td>3.43–1,778</td>
</tr>
</tbody>
</table>

The primary outcome, treatment success, was defined as a combination of 50% or greater reduction in NRS score and PGIC score consistent with “very much improved” or “improved,” and no TKA. A secondary definition of treatment success was also defined based on improvement in NRS score equal to the minimal clinically important change for chronic pain: a two-point reduction [22,23]. MSQ III data were analyzed according to the model.

Conclusions. Genicular C-RFA demonstrated a success rate of 35% based on a robust combination of outcome measures, and 19% of procedures resulted in complete relief of pain at a minimum of six months of follow-up. Report of 80% or greater relief from diagnostic blocks and duration of pain of less than five years are associated with high accuracy in predicting treatment success. Further prospective study is needed to optimize the patient selection protocol and success rate of this procedure.
Prospective, Multicenter, Randomized, Crossover Clinical Trial Comparing the Safety and Effectiveness of Cooled Radiofrequency Ablation With Corticosteroid Injection in the Management of Knee Pain From Osteoarthritis

Tim Davis, MD,* Eric Loudermilk, MD,† Michael DePalma, MD,‡ Corey Hunter, MD,§ David Lindley, DO,¶ Nilesh Patel, MD,** Daniel Choi, MD,†† Marc Soloman, MD,‡‡ Anita Gupta, DO, PharmD,§§ Mehul Desai, MD,|||| Asokumar Buvanendran, MD,*** and Leonardo Kapural, MD, PhD†††

Graphs and images showing pain levels and treatment response over time.
Prognostic Blocks?

- A Prospective Randomized Trial of Prognostic Genicular Nerve Blocks to Determine the Predictive Value for the Outcome of Cooled Radiofrequency Ablation for Chronic Knee Pain Due to Osteoarthritis.

- McCormick ZL, Reddy R², Korn M³, Dayanim D⁴, Syed RH⁵, Bhave M⁶, Zhukalin M⁷, Choxi S⁸, Ebrahimi A⁹, Kendall MC¹⁰, McCarthy RJ¹³, Khan D³, Nagpal G³, Bouffard K⁴, Walega DR³.

29 subjects -> Prognostic Block* -> CRFA = 58.6% pain responders**

25 subjects -> NO BLOCK -> CRFA = 64.0% pain responders

* Block volume 1 ml

**Responder Rate - ≥ 50% pain relief at 6 months; WOMAC Osteoarthritis Index responders also 55 and 60% respectively
Radiofrequency techniques to treat chronic knee pain: a comprehensive review of anatomy, effectiveness, treatment parameters, and patient selection

Predictors of success
- Medial compartment osteoarthritis and concordant pain
- Large and/or multiple lesions
- Controlled prognostic blocks

Predictors of failure
- Greater disease burden (e.g., longer duration of symptoms, greater disability)
- Previous surgery
- Opioid use
- Psychopathology
- Diffuse pain symptomatology (fibromyalgianess)
Complications and Side Effects

- Hypoesthesia
- Superficial / Skin burn
- Hematoma
- Arterial Injury / Osteonecrosis
- Septic Arthritis
- Pes Anserine Tendon Injury


Genicular RFA / Knee OA Outcomes

- Articular sensory nerves emerge from several branches the femoral, sciatic obturator N:\(^1,2,3\).
- Two early randomized, sham controlled RCT’s of RFA showed responders of up to 12 weeks.
- CRFA has been studied; a prospective study demonstrated 19% chance of complete pain relief, as well as a 35% chance of minimum clinically important difference:
  - “improved” global perceived effect, >= 50% NRS pain improvement, and avoidance of surgery\(^4\).
- Genicular CRFA compares favorably to corticosteroid injection in providing a higher responder rate at 6 and 12 months with better functional improvement from OA\(^5,6\).
- Cryoneurolysis may also out-perform sham control for up to 90 days\(^7\).
- PRP may outperform viscosupplementation with Hyaluronic Acid\(^8\).
- Pre-operative ablation did not appear to improve pain outcomes after TKA\(^9\).

Obturator and Femoral Articular Nerve Ablation For Chronic Hip Pain
The sensory innervation of the hip joint - An anatomical study

K. Birnbaum¹, A. Prescher², S. Heßler¹ and K.-D. Heller¹


• Anteromedial joint: obturator nerve
• Anterolateral joint: femoral nerve
• Posterosuperior joint: sciatic nerve
• Posteroinferior joint: nerves to quadratus femoris muscle*
• Posterolateral joint: superior gluteal nerve†

Case Series of Hip Denervation

- N = 14 patients; Single diagnostic block: nerve/joint; RFA: obturator in 9, obturator and femoral in 5; mean VAS: 6.8 to 2.7
- 86% had 50% relief for 1-11 months

- N = 16 pts; 8 pts ≥ 50% pain relief at 6 months;
- Statistically significant improvement in WOMAC scores.

- N: 62 screens w diagnostic blocks, 52 recommended to proceeded to RFA (>50% pain relief from block), 23 met inclusion (180 day f/u, completed RFA)
- 52 Hip denervations performed, no vascular complications, 1 case of neuritis/groin pain x1 week
- Ultrasound used in combination with fluoroscopy
- Mean VAS pain score 7.6 → 2.3 (p < 0.01); First RFA gave “pain relief” from 30-320 days.
- Mean ~ 150 d
Hip Articular Nerve Ablation and Outcomes

• The obturator and femoral nerve send articular nerve branches to the anterior hip joint\(^1\). The posterior hip is innervated at least by the nerve to quadratus femoris and the superior gluteal nerve.

• The anterior nerves have been ablation targets in an attempt to palliate severe, non-operable hip pain. Analogous diagnostic paradigms for diagnostic nerve blocks are applied.

• Several case series of SRFA suggest some promise for ablation over the superior portion of the acetabulum and inferomedial portion of the acetabulum.

• Femoral nerve and arterial injury have occurred\(^2\).

• No RCTs are available as of the time of this review.

• CRFA has been developed for this procedure; case series of 23 patients showed mean “pain relief” duration \(~150\) days (30-320) and no major complications.\(^3\)

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Cervical Zygapophyseal Joint Ablation for Chronic Cervical Spine Pain (New Targeting?)
Cervical Facet Syndrome

• Axial Pain of the Cervical Spine with regional radiation
  • Incidence increases later adulthood.

• Cervical medial branch nerves
  • Lie in the waist of the articular pillars of the cervical spine as they emerge from the nerve root and course posteriorly to the facet joint\(^1\).
  • The vertical distribution of medial branches varies with spine level; best lesions may be achieved somewhat more cephalad at the C7, C6, and C3 levels; while other levels have a relatively central target.
  • Motor testing may result in local spine muscle twitch, but where applicable there should be no upper extremity movement.
  • A small number of patients may have dysesthesias or burning sensation in the overlying skin after the procedure. Severe but rare complications include dropped head syndrome and progressive kyphosis\(^2,3\).

Cervical Facet Denervation

- 58-74% pain relief at 12 months in prospective studies.\(^1\)

- **Paraspinal tenderness** only clinical factor that predicts better success (vs. opioids, pain w/extension or occipital radiation).\(^2\)

- Double Blind, Sham Controlled RCT, n=24 from 54.\(^3\)
  - **3 controlled blocks** (normal saline, lidocaine, bupivacaine)
  - Prognostic block successful if -> **100% pain relief**
  - C3/4 through C6/7 eligible; **C2/3 excluded.**
  - Extensive **3 hour procedure** w/multiple lesions per level
  - Median time >50% Pain Relief **263 v 8 days**.

Cervical Spine Updates

• Quantitative Neuroanatomy (Kweon 2014)
  • Medial Branch – double branches – esp. C4, C5
  • Lateral Branch and relation to posterior tubercle
  • Size – up to 1.2 +/- 0.2 mm (C4, C5)
  • Angle of approach – cephalad-anterior slope
  • Discussions:
    • Consider double lesions
    • Anterior/posterior, Superior/inferior landmarks
    • Straight and curved needles
    • Parasagittal vs oblique approaches

• Vascular Anatomy (Finlyason 2016)
  • Mean Diameter 1.25 mm
  • Implications for injections / procedures


Evidence: Case reports
Sacroiliac Joint Ablation for Chronic Sacroiliac Pain (New Targeting?)
Sacroiliac Joint Pain

• Chronic sacroiliac (SI) joint pain remains a challenge for diagnosis
• Physical exam maneuvers are notably non-specific in the identification of sacroiliac joint pain. (PSIS tenderness, Faber maneuver, etc.)
• Portions of the innervation of the sacroiliac joint are dorsal and accessible to block or RFA\(^1\), yet some are ventral and not accessible.
• Lateral branch nerves emerge from the sacral foramina and course over the sacrum in variable depths, laterally to the sacroiliac joint.
• The concentration of neural innervation appears to be near S1 and S2, but can include S3 and the dorsal ramus of L5\(^1\).
• Controlled diagnostic blocks are believed to be the best method to prognosticate suitability for lateral branch RFA.

## Sacral Lateral Branch Anatomy

<table>
<thead>
<tr>
<th>Author</th>
<th>Dorsal Rami Contribution</th>
<th>Ventral Rami Contribution</th>
<th>L5 contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solonen, 1957</td>
<td>S1 and S2</td>
<td>Yes (L4, L5 and S1)</td>
<td>Yes</td>
</tr>
<tr>
<td>Ikeda, 1991</td>
<td>L5, S1-S4</td>
<td>Yes (L5 and S2)</td>
<td>Yes</td>
</tr>
<tr>
<td>Grob et al, 1995</td>
<td>S1-S4</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Yin et al, 2003</td>
<td>L5, S1-S3</td>
<td>Not studied</td>
<td>Yes</td>
</tr>
<tr>
<td>McGrath and Zhang, 2004*</td>
<td>S2-S4</td>
<td>Not studied</td>
<td>Not studied</td>
</tr>
<tr>
<td>Szadek et al, 2008†</td>
<td>Not studied</td>
<td>Yes (L4 and L5)</td>
<td>Yes</td>
</tr>
<tr>
<td>Willard et al, 2010</td>
<td>L5, S1-S4</td>
<td>Not studied</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Yin et al, 2003
Cohen and Adibi, 2003
Gray, 1918

Sacral Lateral Branch SRFA
At 3-month follow-up, 47% of treated patients and 12% of sham subjects achieved treatment success. At 6 and 9 months, respectively, 38% and 59% of treated subjects achieved treatment success.
No radicular etiology / spinal stenosis

LBP >3 months

2x SI joint injections using 3mL of local anesthetic and 40mg triamcinolone.

>50% pain relief
New understanding

Innervation of the Anterior Sacroiliac Joint

Marcus Cox, Garrett Ng, Faizullah Mashriqi, Joe Iwanaga, Fernando Alonso, Kevin Tubbs, Marios Loukas, Rod J. Oskouian, R. Shane Tubbs

Cadaveric Study of Sacroiliac Joint Innervation: Implications for Diagnostic Blocks and Radiofrequency Ablation

Shannon L. Roberts, BA, Robert S. Burnham, MD, MSc, Kajeerana Ravichandiran, MD, MSc, Anne M. Agar, PhD, and Eldon Y. Loh, MD

L5 VR: 80%      L4 VR: 10%      Both: 10%
Evidence for Sacroiliac Joint Ablation

• Outcomes for SRFA of the SI joint show low evidence for intermediate term (1-6 mo) improvement in pain\(^1\).

• Recent meta-analysis including 7 cooled RFA trials of mixed retrospective and prospective or placebo controlled design spanning follow-up of 3-24 months
  • Mean reduction in pain of about 3.8 points on NRS
  • Modified Oswestry Disability scale improvement of 18 points after treatment
  • More high quality prospective study needed to improve the power of the findings\(^2\).

• Sham Controlled RCT exists, treatment outcomes diverge by 3-9 months\(^3\).

• Multipolar RFA has observational data and requires more prospective study\(^4\).

---

Lumbar Zygapophyseal Joint Ablation for Chronic Low Back Pain
Lumbar Facet Denervation (medial branches)

• Long term treatment for “facetogenic” low back pain:
  • Segmental tenderness of the low back
  • Pain with provocation of the facet joints (quadrant loading, prone hip extension, palpation)
  • Concordant, positive response to controlled diagnostic medial branch blocks
    • >50% relief vs. >80% or more
  • Absence of radicular pain
Lumbar Medial Branch SRFA: Evidence

• **Metanalysis of outcomes:**
  • Short term improvement (1 mo.) v. placebo, pain and function: “moderate quality evidence”\(^1,2,3\)
  • Longer duration benefit (>1 mo.): “weak evidence”
  • Outcomes tend to be better when using greater diagnostic nerve block specificity

• **Sham controlled study (n=40 / 376) by Nath\(^4\):**
  • Improved pain back pain scores at 6 months (by 2.1 NRS points compared to 0.7 for placebo), back movement, hip movement, and quality of life variables in treatment group;
  • Included subjects had >80% relief with blinded diagnostic blocks containing lidocaine and bupivacaine with concordant duration of action.
  • RFA was performed parallel to the anatomic course of the medial branch nerves
  • 22g cannula with 5mm active tip.

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Lumbar Cooled RFA

Evidence: Case reports
Thoracic Zygapophyseal Joint Ablation for Chronic Thoracic Spine Pain
Thoracic Facet Joint Syndrome

• Segmental, Axial Pain of the Thoracic Spine
  • Paraspinal Tenderness
  • May radiate anteriorly
• Lower prevalence than cervical and lumbar
• Medial Branch (MB) passes fairly laterally to the tip of the Transverse Process as it comes inferior and dorsal
• Lack of significant high level evidence for TRFA
• Same principles of selection and proper procedural technique apply.
  • Additional possible risk of pneumothorax
  • Nerve root injury may be less problematic

Renditions: Thoracic Medial Branches

- **T1-4, 9-10**
  - Lateral on TP
- **T5-8**
  - Superior and Medial to tip TP
- **T11, T12**
  - Near root of SAP

*Chua WH, Bogduk N. 1995;136(3-4):140-4.*
Thoracic Facet Denervation: Cooled RFA

Evidence: Case reports
Summary: Technical Advances in RFA

• **Quantitative Anatomy – Improving Targets**
  • Spine / SI Joint
  • New body regions: Knee, Hip, Shoulder

• **RFA and Versatility**
  • Variable success in proving long term outcomes
    • Cervical Spine > Lumbar Spine > Sacroiliac Joint
  • Emerging data for Major Joints
    • Knee > Hip > Shoulder

• **Technical Advancement - Larger Lesion Sizes**
  • Possibly improved outcomes
  • New complications
  • Safe trajectories are needed
Thank you team!