Decision Analysis: Applications in Orthopaedics

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Analysis of Orthopaedic Treatment Decisions

- **Three Applications:**
  - Patellar Resurfacing in Total Knee Replacements
  - Treatment of Clavicle “Collar Bone” Fractures
  - Surgical Treatment of Lisfranc Injuries
Analysis of Orthopaedic Treatment Decisions

- **Gameplan**
  - Introduction and Anatomy
  - Medical Literature Review and Data
    - Cost Estimates & Probabilities
  - Analysis and Results
    - Decision Tree and Sensitivity Analysis
    - **PAYER PERSPECTIVE**
  - Discussion/Questions
Total Knee Replacement

- Total Knee Arthroplasty (TKA) is a high volume procedure
- Estimated to be 3.48 million per year in 2030 (Kurtz et JBJS 2007)
- ~600,000 performed in 2007 with costs exceeding $11 billion (Arch Intern Med. 2009)
Patellar Resurfacing
Patella Resurfacing with TKA?

Physician (Provider):

“Always, Sometimes, Never.”

Government (Payer):

27447
470
Decision Tree Model

TKA

Resurfaced Patella

Nonresurfaced Patella
Decision Tree Model

- Resurfaced Patella
  - Reoperations
  - No Reoperations
  - Instability
  - Aseptic Loosening
  - Fracture
  - Ruptured Extensor Mechanism
  - Other
Decision Tree Model

Nonresurfaced Patella

- Reoperations
  - Anterior Knee Pain
  - Osteonecrosis
- No Further Operations
  - Other
Results

<table>
<thead>
<tr>
<th></th>
<th>Resurfaced</th>
<th>Nonresurfaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Year Expected Cost</td>
<td>$13,788.48</td>
<td>$14,016.41</td>
</tr>
<tr>
<td>Secondary Surgery</td>
<td>0.71%</td>
<td>3.34%</td>
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</tbody>
</table>

Cost Savings of $228 per knee

More likely ~$750/knee
Sensitivity Analysis

Two-way Sensitivity Analysis

Revision rates shown in Figure 1

Chance of Revision for Resurfaced vs. Chance of Revision for not-Resurfaced

- No Resurface
- Resurface

Revised rates shown in Figure 1
Discussion

- Potential Savings
  - 15% Do not routinely resurface
    - AAHKS 2010 Survey
    - 2007 → $20,500,000/year
    - 2030 → $175,000,000/year (Medicare data)
  - Remember Payer’s Perspective!
Clavicle “Collar Bone” Fractures
Treatment of Clavicle Fractures

- **Background Data**
  - 3-4% of all adult fractures
  - 80% occur in the middle 1/3
  - Peak incidence in males under 30

  *McKee et al. JBJS Am 2006*

- **Traditionally treated non-op**
  - Retrospective data from 1960s
    - Low rates of nonunion (1%)
    - Included adolescents

  *Neer JAMA 1960*
  *Rowe CORR 1968*
Clavicle Fractures

- **New Study Results**
  - Higher rates of nonunion (up to 15%)
  - Decreased patient satisfaction

- **Biomechanics**

- **Advantages & Disadvantages**

  *Hill et al. JBJS Br 1997*  
  *Ledger et al. JSES 2005*

- **Trends**
  - Synthes - domestic clavicle plate sales
    - 2009 - 11,630 Units
    - 2010 - 15,640 U (34% inc)
    - 2011 - 17,430 U (12% inc)
    - 2012 - 18,180 U (4.5% inc)
    - 2012- 56% inc over 2009
Decision Tree Model

Displaced Midshaft Clavicle Fracture

Operative Treatment

Nonoperative Treatment
Decision Tree Model

Operative Treatment

- Reoperations
  - HWR
  - HWR with I&D
  - Revision ORIF
  - Nonunion
- No Reoperations
Decision Tree Model

Nonoperative Treatment

Delayed Operative Procedure

No Further Operations

ORIF

ORIF Malunion

ORIF Nonunion

No Further Operations
Results

- Decision tree analysis expected costs
  - Operative treatment- $14,763.21
  - Nonoperative treatment- $3,112.65

- Projected cost savings of $11,650.56/clavicle fracture
Results

- Sensitivity Analysis
  - 2-way analysis varying rates of reoperation and delayed operative treatment
  - Model remained stable over a wide range of probabilities

Two-way Sensitivity Analysis, Medicare Costs

- \( x = 0.1871 \) \( y = 0.2348 \)

Graph showing the relationship between the probability of delayed surgery after non-OP treatment and the probability of OP treatment.
Discussion

- Potential Savings
  - $11,650 per fracture

- How many fractures are there?
  - Incidence 24-71 fractures / 100,000 population
    - Mueller *J Trauma* 2008
    - Robison *JBJS* 1998

- Let’s do the math...
  - US ~325,000,000
  - 78,000 – 230,750 / per year
  - 80% occur in the midshaft
  - 62,400 – 184,600 fractures/year
  - $727 Million – $ 2.15 Billion in healthcare savings
Lisfranc Injuries
Lisfranc Injuries

- What’s the Big Deal?
  - Imperative to maintain normal foot biomechanics and function
  - Untreated injuries
    - Persistent pain
    - Progressive deformity
    - Prolonged disability
Lisfranc Injuries

- Surgery
  - Two Options
    1. Open Reduction Internal Fixation (ORIF)
    2. Primary Arthrodesis
Surgical Treatment of Lisfranc Injuries

Does Open Reduction and Internal Fixation versus Arthrodesis Improve Patient Outcomes for Lisfranc Injuries: A Systematic Review and Meta-analysis

Nicholas Smith MD, MSc, Craig Stone MD, MSc, FRCSC, Andrew Furey MD, MSc, FRCSC

Open reduction and internal fixation compared with primary arthrodesis of Lisfranc injuries: a systematic review of the literature

Charlie Lee

Arthrodesis Versus ORIF for Lisfranc Fractures

Shahin Sheibani-Rad, MD, MS; J. Christiaan Coetzee, MD; M. Russell Giveans, PhD; Christopher DiGiovanni, MD
Cost Estimation

- Where you have your surgery matters!!!
  - Two decision tree models
    - Outpatient Hospital (APC)
    - Outpatient Ambulatory Surgery Center (ASC)
Data

- What Does the Literature Say?

Open Reduction Internal Fixation Versus Primary Arthrodesis for Lisfranc Injuries: A Prospective Randomized Study

Jeffrey A. Henning, MD; Clifford B. Jones, MD, FACS; Debra L. Siesema, PhD; Donald R. Bobay MD, FACS; John G. Anderson, MD

Severe Lisfrancs Injuries: Primary Arthrodesis or ORIF?

Thomas Mulier, M.D.; Piet Reynders, M.D., Ph.D.; Greta Dereymaeker, M.D., Ph.D.; Paul Broos, M.D., Ph.D.

Leuven, Belgium
Basic Decision Tree Analysis

- **APC Expected Costs:**
  - **ORIF**
    - $18,613
  - **PA**
    - $19,803
  - **Expected Savings**
    - $1,190
Basic Decision Tree Analysis

- **ASC Expected Costs:**
  - ORIF: $11,652
  - PA: $11,703
- **Expected Savings:** $51
### Results

#### Table 3 One-way Sensitivity Analysis Intersection Points

<table>
<thead>
<tr>
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<th>Initial Cost/Percentage</th>
<th>Indifference Point</th>
<th>Percent Change</th>
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<tbody>
<tr>
<td><strong>ORIF Cost APC</strong></td>
<td>$13,611.29</td>
<td>$14,801.80</td>
<td>(+) 8.7%</td>
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<tr>
<td><strong>ORIF Cost ASC</strong></td>
<td>$8,335.59</td>
<td>$8,387.12</td>
<td>(+) 0.62%</td>
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<tr>
<td><strong>Primary Arthrodesis Cost APC</strong></td>
<td>$18,165.50</td>
<td>$16,974.99</td>
<td>(-) 6.55%</td>
</tr>
<tr>
<td><strong>Primary Arthrodesis Cost ASC</strong></td>
<td>$10,662.66</td>
<td>$10,611.13</td>
<td>(-) 0.48%</td>
</tr>
<tr>
<td><strong>Probability of HWR after ORIF APC</strong></td>
<td>60%</td>
<td>74%</td>
<td>(+) 23.33%</td>
</tr>
<tr>
<td><strong>Probability of HWR after ORIF ASC</strong></td>
<td>60%</td>
<td>61%</td>
<td>(+) 1.67%</td>
</tr>
<tr>
<td><strong>HWR Cost ASC</strong></td>
<td>$3,394.82</td>
<td>$3,497.48</td>
<td>(+) 3.02%</td>
</tr>
<tr>
<td><strong>Probability of Secondary Surgery after PA ASC</strong></td>
<td>17.65%</td>
<td>16.78%</td>
<td>(-) 4.92%</td>
</tr>
</tbody>
</table>
Sensitivity Analysis: Costs

(+) $1,190.51 (+8.7%)

(-) $1,190.51 (-6.55%)

(+) $102.66 (+3.02%)
Sensitivity Analysis: Probabilities

60% → 74% (Δ 23.33%)

17.65% → 16.78% (Δ -4.92%)
Two-Way Sensitivities

**APC: ORIF Cost vs Rate of HWR after ORIF**

- Rate of HWR after ORIF
- ORIF Cost

**ASC: ORIF Cost vs Rate of HWR after ORIF**

- Rate of HWR after ORIF
- ORIF Cost

**APC: Primary Arthrodesis Cost vs Rate of HWR after ORIF**

- Rate of HWR after ORIF
- Primary Arthrodesis Cost

**ASC: Primary Arthrodesis Cost vs Rate of HWR after ORIF**

- Rate of HWR after ORIF
- Primary Arthrodesis Cost
Sensitivity analyses reveals which **inputs** influence the decision policy.

Outcomes can change with small differences in costs or probabilities.
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- Three Applications:
  - Patellar Resurfacing in Total Knee Replacements
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Conclusions

1. Patella resurfacing during primary TKA is the optimal financial strategy from a Medicare perspective over a mid term period.
Conclusions

2. Initial nonoperative management of mid shaft clavicle fractures is the optimal financial strategy from the payer perspective.
Conclusions

3. **Surgeon discretion** is the optimal surgical solution for each unique Lisfranc injury pattern
Publications
DISCUSSION & QUESTIONS
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