THE NATURAL HISTORY OF RAY AMPUTATIONS

Third Annual Diabetic Foot Update
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PARTIAL RAY AMPUTATIONS

OBJECTIVES

**WHO:** Incidence / Demographics

**WHAT:** Causative factors

**WHEN:** Biomechanics

**WHERE:** Global differences

**WHY:** Predictors of outcome

**HOW:** Increase survivability
PARTIAL RAY AMPUTATIONS
MAGNITUDE OF THE PROBLEM

- 12 month re-amputation rates and associated costs - 1996 Medicare data
- 25.3% re-amputation among DM with toe level amp with >40% these cases resulted in trans-tibial level
- 22.7% mortality rate
- Average total cost $45,513
- Amputation rates are highest among:
  - Men
  - Racial and ethnic minorities
  - Older people
- Previous amputations are strong predictors of future amputations

PARTIAL RAY AMPUTATIONS INCIDENCE

United States
- African Americans 2 fold excess risk for LEA compared to Caucasians

United Kingdom
- African Caribbeans 1/3 lower risk compared with Europeans in London

Caribbean (Barbados)
- LEA rates for African Caribbeans overall similar to US

PARTIAL RAY AMPUTATIONS
INCIDENCE

- Abstracted medical records 1993 six metro areas: San Antonio, Corpus Christi, Brownsville, McAllen, Laredo, and Victoria
- 1,944 LEA during 1,228 hospitalizations
- 477 (45.7%) foot level
  - 305 males
  - Mean age 61.3 years
- 37.3% previous LEA
- No statistically significant differences in age, race, ethnicity
- 62.7% diagnosed with PAOD

Level of Foot Amputation

<table>
<thead>
<tr>
<th>Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Ray</td>
<td>28%</td>
</tr>
<tr>
<td>2nd Ray</td>
<td>14%</td>
</tr>
<tr>
<td>3rd Ray</td>
<td>10%</td>
</tr>
<tr>
<td>4th Ray</td>
<td>9%</td>
</tr>
<tr>
<td>5th Ray</td>
<td>14%</td>
</tr>
<tr>
<td>Multiple</td>
<td>6%</td>
</tr>
</tbody>
</table>
PARTIAL RAY AMPUTATIONS
CAUSATIVE FACTORS

- Ulceration / Infection
  - Neuropathy
  - Increased Plantar Pressure
  - Prolonged Activity
  - Foot Deformity
- Gangrene
- Failed toe amputation
- Chronic ulceration / tissue loss
- Trauma
- Intolerable pain
- Malignancy
PARTIAL RAY AMPUTATIONS
SURGICAL MANAGEMENT

Biologic Amputation Level

*The most distal functional amputation level with a reasonable (85% - 90%) potential to support wound healing*

- Vascular inflow
  - ABI
- Tissue Nutrition
  - TcPO2
    - Pre-albumin
    - Protein
  - Immuno-competence
    - TLC
- incision planning
- no purulence
- open vs. closure
- marginal tissue

Pinzur, MS et al, “Amputation Level Selection in the Diabetic Foot” Clin Ortho Rel Research, 1993
PARTIAL RAY AMPUTATIONS
TECHNIQUE

- Dorsal incision over metatarsal shaft
- Racquet around digit
- Plantar ulceration ellipse
- Transect metatarsal 45 degree bevel
- Examination of all tissue planes
- Extensive irrigation
- Primary vs. delayed closure
- Closure with mattress sutures
Hypertrophic Bone Re-growth

- Increase risk of re-ulceration / re-amputation
- 92 patients isolated ray resections
- Repeat radiographs at mean 22 months
- Hypertrophic Bone >3mm
- 41 patients (45%) had hypertrophic bone formation
- Significant factors associated with re-growth:
  - Male gender
  - Manual bone cutting instruments
  - Resection distal to the surgical neck
- Re-growth of bone 8x more likely to re-ulcerate at amp site

PARTIAL RAY AMPUTATIONS
INCIDENCE AND SURVIVAL

- 277 patients retrospectively reviewed first LE amputation between 1993 – 1997
- Re-amputation episodes recorded through 2003
- Toe, Ray, Mid-foot, Major Amputation levels

Data for Ray Resections
n = 114 (41%)
81 males (71.1%)
95 Hispanic (83.3%)
Age 52.4 yrs
PAD 34 pts (29.8 %)
ESRD 4 pts (3.5%)
27 revasc. (23.7%)
59 smokers (51.7%)
29 Deceased (25.4%)
Average f/u 5.4 yrs

PARTIAL RAY AMPUTATIONS
INCIDENCE AND SURVIVAL


Rates of Re-amputation for Partial Ray Resections

<table>
<thead>
<tr>
<th></th>
<th>Ipsilateral</th>
<th>Contralateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>28.7%</td>
<td>9.3%</td>
</tr>
<tr>
<td>3 years</td>
<td>41.2%</td>
<td>21.6%</td>
</tr>
<tr>
<td>5 years</td>
<td>50%</td>
<td>29.2%</td>
</tr>
</tbody>
</table>
### PARTIAL RAY AMPUTATIONS INCIDENCE AND SURVIVAL

- **53 Diabetic Miami VA veterans**
- **Success rate @ average 22.3 months**
  - 93% TMAs
  - 86% pan-metatarsal head resection
  - 37% partial ray resection

<table>
<thead>
<tr>
<th>Ray Resection</th>
<th>Total</th>
<th>Success</th>
<th>Failure</th>
<th>%Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>11</td>
<td>4</td>
<td>7</td>
<td>36.4</td>
</tr>
<tr>
<td>2nd</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>14.3</td>
</tr>
<tr>
<td>3rd</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>16.8</td>
</tr>
<tr>
<td>4th</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>5th</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>77.8</td>
</tr>
<tr>
<td>total number</td>
<td>35</td>
<td>13</td>
<td>22</td>
<td>37.1</td>
</tr>
</tbody>
</table>

PARTIAL RAY AMPUTATIONS INCIDENCE AND SURVIVAL

- 85 patients reviewed
- 1993 – 1995
- 64 (75%) male
- Avg age 53.7 years
- Avg follow-up 33 mos
- Avg dur of DM 14.3 years
- 82 (96%) Type 2 DM
- 82 % Hispanic

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percent</th>
<th>Success</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Ray</td>
<td>31</td>
<td>36.5</td>
<td>18</td>
<td>58</td>
</tr>
<tr>
<td>2nd Ray</td>
<td>7</td>
<td>8.2</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td>3rd Ray</td>
<td>7</td>
<td>8.2</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td>4th Ray</td>
<td>10</td>
<td>11.8</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>5th Ray</td>
<td>20</td>
<td>23.5</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>Multiple</td>
<td>10</td>
<td>11.8</td>
<td>5</td>
<td>50</td>
</tr>
</tbody>
</table>

Diagnosis at Initial Amputation

Osteomyelitis 49 (57.6%)  Soft Tissue Infection  22 (25.9%)  Critical Ischemia  14 (16.5%)

Reyzelman, et al, *Unpublished*
# PARTIAL RAY AMPUTATIONS
## INCIDENCE AND SURVIVAL

<table>
<thead>
<tr>
<th>Type</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same level</td>
<td>50 (58.8%)</td>
</tr>
<tr>
<td>More Proximal</td>
<td>35 (41.2%)</td>
</tr>
<tr>
<td>TMA/Chopart</td>
<td>22 (62.8%)</td>
</tr>
<tr>
<td>BKA/AKA</td>
<td>13 (37.2%)</td>
</tr>
</tbody>
</table>

### Diag at Subsequent Amp

- **Infection**: 17 (48.6%)
- **Infection w/ Ischemia**: 17 (48.6%)
- **Inadequate skin coverage**: 1 (2.9%)

### Revascularization

- 16 patients (18.8%)
  - Underwent peri-operative distal LE revascularization
    - 11/16 revasc. *PRE-amp*
    - 19% went on to major amputation
    - 5/16 revasc. *POST-amp*
    - 100% went on to major amputation
- 13/13 (100%) of patients that progress to major amputation – ISCHEMIA
  - 11x increase chance of proximal amputation

*Reyzelman, et al, Unpublished*
5 studies -- 435 Patients underwent 1st ray amputations

- Mean f/u 26 months
- Mean Age 59
- 19.8% re-amputation rate
  - 37.2% Additional digit
  - 32.6% TMA
  - 29.1% BKA
  - 1.2% Lisfranc

**Conclusion:** One out of every 5 patients undergoing a partial first ray amputation subsequently require a more proximal amputation to achieve a durable, weight bearing residual extremity.

Retrospective review
59 Patients underwent 1st Ray amputations
- Mean f/u 33.8 months
- Mean Age 67
- 47.5% Mortality at mean 34.6 months
- 69% develop a foot ulcer mean 10.5 months
  - Prolonged clinic visits
  - Multiple antibiotic prescriptions
  - Ancillary surgical procedures
- 42.4% re-amputation rate at mean 25 months
  - 36% BKA
  - 24% TMA
  - 16% additional digit
  - 8% midshaft first metatarsal
  - 8% 1st MPJ
  - 4% AKA
  - 4% Chopart

Conclusion: “We believe the partial first ray level of amputation is neither reliable nor durable.”

PARTIAL RAY AMPUTATIONS
BIOMECHANICS

- Loss of medial column integrity
- Medial arch collapse
- Adjacent toes attempt to supply stabilization
- Development of digital contractures
- Plantar prominences of the metatarsal heads due to retrograde buckling and displacement of the fat pad
PARTIAL RAY AMPUTATIONS
BIOMECHANICS

- 11 NIDDM patients unilateral partial 1st ray amputations >6 months
- F-scan measurements
- Risk Factors are unchanged

<table>
<thead>
<tr>
<th>Peak Pressure (g/cm²)</th>
<th>Great Toe Amp</th>
<th>No foot Amp</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Met</td>
<td>6,329 +/- 4,658</td>
<td>4,611 +/- 2,511</td>
</tr>
<tr>
<td>Lesser Mets</td>
<td>8,267 +/- 3,909</td>
<td>4,935 +/- 2,557</td>
</tr>
<tr>
<td>Lesser Toes</td>
<td>3,666 +/- 2,704</td>
<td>1,701 +/- 1,229</td>
</tr>
<tr>
<td>Heel</td>
<td>3,604 +/- 1,424</td>
<td>4,323 +/- 1,782</td>
</tr>
</tbody>
</table>

Lavery LA et al, “Increased Foot Pressures After Great Toe Amputation in Diabetes” Diabetes Care 1995
PARTIAL RAY AMPUTATIONS
DISTAL AMPUTATION VALUE

- Lower rate of mortality
  - 5% vs. 21% 1 year
- Lower rate of new major amputation
- Higher rehabilitation potential
  - 70% vs. 19% walk 1km
  - 93% vs. 61% return home
  - 40% regular use of prosthesis

Conclusion:
Despite a longer healing time (29 vs. 8 weeks) and high re-amputation rates, long term results are more favorable with minor vs. major amputations

NATURAL HISTORY OF PARTIAL RAY AMPUTATIONS

CONCLUSIONS

Pre-Op
- ABI
- TcPO2
- Serum Albumin > 3.0 g/dl
- Serum Protein level >6.0g/dl
- Total Lymphocyte Ct >1500ml
- Rehabilitation Potential

Intra-op
- Incision planning
- Meticulous handling of skin and soft tissue
- Power Instrumentation
- Adequate debridement
- Closure without tension

Post-op
- Compliance with wound care and offloading
- Careful discharge planning
- Identification of High Risk Patients
- Multispecialty High Risk Foot Clinics

Preventive
- Intense Education / Proper Foot Care
- Promotion of early health-care seeking behaviors
- Blood Glucose Control
- Shoegear
- Adjunct Procedures