Paul Manning
Nottingham University Hospitals

THE ROTATOR CUFF
CURRENT CONCEPTS
ARTHROSCOPIC REPAIR
Summary

- Simple Anatomy
- Types of Tear
- Arthroscopic Repair
  - Anchors
  - Patient Physiology
  - Repair Configuration
  - Rehabilitation
- Conclusion
Anatomical

Rotator cuff muscles

Supraspinatous muscle

Subscapularis muscle

Infraspinatous muscle

Teres minor muscle

Anterior shoulder

Posterior shoulder
Anatomical
Types of Tear
Small/Medium
< 3cm
<60 Wear and Tear
<60>45 Post Dislocation

Best Candidates for Repair
Massive Tear

>5cm

- >60
Treatment of Massive Tears

- Deltoid Rehabilitation
- Repair with Orthobiologic Material
  - Platelet Rich Plasma
- Muscle Transfers
- Arthroscopic Subacromial Decompression and Cuff Debridement/Biceps Tenotomy
  - 80% Good/Excellent results for pain (not function) (Gartsman)
- Reverse Arthroplasty
Partial Tears
PASTA Lesions
PASTA

- Young
- Painful
- Debride
- Beware Stiffness
Subscapularis

- Rare, liked by examiners
Arthroscopic Repair
Small & Medium Tears

- Current Concepts
Cuff integrity after arthroscopic versus open rotator cuff repair
Julie Bishop 2006

- Prospective study
- MRI scans
- 1-year follow-up
Cuff integrity after arthroscopic versus open rotator cuff repair: A prospective study
Julie Bishop 2006

- Cuff integrity is comparable for small tears
Cuff integrity after arthroscopic versus open rotator cuff repair: A prospective study
Julie Bishop 2006

- Large/Massive tears have twice the retear rate after ARCR
Arthroscopic Cuff Repair
The Next Generation in Bioabsorbable Soft Tissue Reattachment Implants.
Arthroscopy June 2002

BIOKNOTLESS™ Anchor

Fully absorbable PLA anchor is preloaded with PANACRYL™ long-term braided absorbable suture.

CUFFTACK™

CUFFTACK absorbs after healing with high cyclic load strength.
IT'S NOT YOUR ORDINARY SUTURE ANCHOR

The UltraFix® Knotless MiniMite® Suture Anchor, redefining ease-of-use in knotless technology.
**Double Row Rotator Cuff Repair**
- No knot tying
- No suture passing

**VERSALOK™ MY WAY**

T.K. Miller, MD
Roanoke Orthopaedic Center/Roanoke Ambulatory Surgery Center, Roanoke, VA

Jeffrey Rosen, MD
NYU Hospital for Joint Diseases
New York, NY

Christopher P. Piller, MD
Habib Clinic Orthopaedics
Rome, GA

Arthroscopy 2007
Figure K13: Cumulative percentage of Revision of Unicompartmental Knee Prostheses
Sutures and suture anchors: update 2003

Barber 2003

- Anchors should not represent the weakest portion of a repair.
Newton's

<table>
<thead>
<tr>
<th>Product</th>
<th>Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UltraSorb*</td>
<td>174</td>
</tr>
<tr>
<td>BioCorkscrew 6.5*</td>
<td>181</td>
</tr>
<tr>
<td>BioCorkscrew 5.0*</td>
<td>222</td>
</tr>
<tr>
<td>AlloAnchor RC</td>
<td>268</td>
</tr>
<tr>
<td>Duet*</td>
<td>336</td>
</tr>
<tr>
<td>TwinFix Ti 5.0</td>
<td>442</td>
</tr>
<tr>
<td>TwinFix Ti 3.5</td>
<td>448</td>
</tr>
<tr>
<td>SuperRevo</td>
<td>468</td>
</tr>
<tr>
<td>TwinFix AB*</td>
<td>485</td>
</tr>
<tr>
<td>Opus Magnum</td>
<td>509</td>
</tr>
</tbody>
</table>

* Bioabsorbable material

Barber 2003
Sutures and Suture Anchors—Update 2006
Barber 2006
- Higher load to failure
- Screw-type versus nonscrew designs
Fixation of knotless suture anchors
Brown 2008

- The three suture anchors tested
  - Opus Magnum
  - Mitek Bioknotless RC
  - Smith & Nephew TwinFix 5.0 Titanium.
Suture Anchor Materials, Eyelets, and Designs: Update 2008
F. Alan Barber

- Suture anchors were tested in fresh porcine
- Cortical
- Cancellous Bone
Table 1. Suture Anchor Properties

<table>
<thead>
<tr>
<th>Anchor</th>
<th>Material</th>
<th>Suture</th>
<th>Load</th>
<th>Minor (mm)</th>
<th>Major (mm)</th>
<th>Length (mm)</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinsa</td>
<td>PEEK</td>
<td>No. 2 Ultrabraid</td>
<td>Single</td>
<td>2.9</td>
<td>3.4</td>
<td>15.14</td>
<td>3.0 tapered drill</td>
</tr>
<tr>
<td>Kinsa RC 5.5</td>
<td>PEEK</td>
<td>No. 2 Ultrabraid</td>
<td>Single</td>
<td>3.5</td>
<td>5.5</td>
<td>15.0</td>
<td>3.8-mm awl</td>
</tr>
<tr>
<td>BioRaptor 2.3PK</td>
<td>PEEK</td>
<td>No. 2 Ultrabraid</td>
<td>Single</td>
<td>2.3</td>
<td>3.0</td>
<td>11.56</td>
<td>2.6-mm drill</td>
</tr>
<tr>
<td>TwinFix PK FT 6.5</td>
<td>PEEK</td>
<td>No. 2 Ultrabraid</td>
<td>Double</td>
<td>3.5</td>
<td>5.5</td>
<td>14.99</td>
<td>3.8-mm awl; also available triple-loaded</td>
</tr>
<tr>
<td>TwinFix PK FT 6.5</td>
<td>PEEK</td>
<td>No. 2 Ultrabraid</td>
<td>Double</td>
<td>3.5</td>
<td>6.5</td>
<td>14.99</td>
<td>3.8-mm awl; also available triple-loaded</td>
</tr>
<tr>
<td>Swivelock C</td>
<td>PLLA, PEEK</td>
<td>2-mm Fibertape</td>
<td>Single</td>
<td>3.7</td>
<td>5.5</td>
<td>15</td>
<td>5.5-mm punch; available with open (forked) and closed eyeholes</td>
</tr>
<tr>
<td>PEEK SutureTak</td>
<td>PEEK</td>
<td>No. 2 FiberWire</td>
<td>Single</td>
<td>2.3</td>
<td>3</td>
<td>12</td>
<td>2.2-2.9 mm stepped drill</td>
</tr>
<tr>
<td>Corkscrew FT II</td>
<td>Titanium</td>
<td>No. 2 FiberWire</td>
<td>Triple</td>
<td>3.7</td>
<td>5.5</td>
<td>16</td>
<td>Also available in 4.5- and 6.5-mm and double-loaded</td>
</tr>
<tr>
<td>Versalok</td>
<td>Titanium, PEEK</td>
<td>No. 2 Orthocord</td>
<td>4 strands</td>
<td>4.9 × 31</td>
<td>Expands to 6.3</td>
<td>4.9 × 27</td>
<td>—</td>
</tr>
<tr>
<td>BioKnotless</td>
<td>PLLA</td>
<td>No. 2 Orthocord</td>
<td>Single</td>
<td>2.9</td>
<td>3.9</td>
<td>9</td>
<td>&quot;Internal&quot; No. 2 Orthocord loop</td>
</tr>
<tr>
<td>BioKnotless BR</td>
<td>Biocryl Rapide</td>
<td>No. 2 Orthocord</td>
<td>Single</td>
<td>2.9</td>
<td>3.9</td>
<td>9</td>
<td>&quot;Internal&quot; No. 2 Orthocord loop</td>
</tr>
<tr>
<td>Healinx Peek</td>
<td>PEEK</td>
<td>No. 2 Orthocord</td>
<td>Triple</td>
<td>3.9</td>
<td>5.5</td>
<td>18</td>
<td>Also available in 4.5- and 6.5-mm; also available double-loaded</td>
</tr>
<tr>
<td>Anchor</td>
<td>No. of Tests</td>
<td>Mean Force (N)</td>
<td>Range (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinsa</td>
<td>7</td>
<td>173.7</td>
<td>101-265.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinsa RC 5.5</td>
<td>10</td>
<td>193.4</td>
<td>84-237</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BioRaptor 2.3 PK</td>
<td>10</td>
<td>76.0</td>
<td>29-116</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TwinFix PK FT 5.5</td>
<td>12</td>
<td>445.7</td>
<td>255-587</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TwinFix PK FT 6.5</td>
<td>12</td>
<td>505.4</td>
<td>344-603</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healix Peek</td>
<td>10</td>
<td>390.1</td>
<td>348-482</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VersaLok</td>
<td>9</td>
<td>379.2</td>
<td>151.2-730</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BioKnotless</td>
<td>4</td>
<td>242.6</td>
<td>203.2-275.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BioKnotless BR</td>
<td>7</td>
<td>268.5</td>
<td>165.3-359</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corkscrew FT II</td>
<td>12</td>
<td>330.3</td>
<td>187-409</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SwiveLock C</td>
<td>12</td>
<td>563.8</td>
<td>134-879</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEEK SutureTak</td>
<td>11</td>
<td>144.8</td>
<td>35-193</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Worst case-Cancellous Bone

- **screw**
  - 350 N

- **The toggle anchors**
  - 165 N

- **expanding bolt designs**
  - 150 N

- **Push-in anchors**
  - 29 N

Barber 2008
Tissue Healing
Tendon Healing
Three phases

1. Inflammatory phase
2. Proliferative phase
3. Maturation and remodelling phase
Inflammatory phase

- the first 7 days
- platelets from blood plasma enter the tear to initiate clot formation
- fragile bond
- Chemotactic mediators attract inflammatory white blood cells
Proliferative phase

- 2 to 3 weeks after tendon repair
- Fibroblasts, myofibroblasts, and endothelial cells, form **granulation tissue**.
- This tissue replaces the original fibrin clot with the scaffolding of a more permanent repair tissue
- Fibroblasts initially produce type III collagen, which is arranged haphazardly in the absence of cross-linking
The maturation and remodeling phase

- Begins week 3 after injury or repair
- Synthetic activity slowly tapers and scar tissue organizes
- Immature type III collagen is replaced by mature type I collagen
- The collagen is continually remodeled until permanent repair tissue is formed
Histology of repair

- Miyahara
  - dog model
  - restored by 24 weeks.

- Gerber
  - goat model
  - no histologically normal infraspinatus tendon-bone interface in a even at 6 months after surgery

- healing rates vary in different animal models
Cortical vs McCloughlin

St Pierre

- Goat
- formation of the collagen fibre-bone interface occurred by 12 weeks
- NO DIFFERENCE whether attached to cortical surface of the greater tuberosity or trough in the tuberosity.
Conclusion

“The surgeon should be aware of performance properties when selecting an anchor or suture”
Barber 2003
Technique

Single layer

Double layer

Trans-osseous

[Images of anatomical structures]
The Footprint
Anatomy and dimensions of rotator cuff insertions
Dugas 2002

15mm
The Footprint
Anatomy and dimensions of rotator cuff insertions
Dugas 2002

1 mm
EM of supraspinatus footprint

Curtis 2006
“Notice how close to the rim of the articular cartilage the fibers are attached and that a few of them in this specimen have given way at the very edge”

The anatomy of the human shoulder

CHAPTER I

Codman 1933
Tendon-to-Bone Pressure Distributions
Transosseous Suture and Suture Anchor Fixation Techniques
*Park* 2005
Tendon-to-Bone Pressure Distributions at a Repaired Rotator Cuff Footprint Using Transosseous Suture and Suture Anchor Fixation Techniques

Maxwell C. Park 2005

- Transosseous
- TOS
- 68mm$^2$
Suture Anchor Mattress SAM
26mm²
- Suture Anchor Simple
- SAS
- 34.1 mm²
Interface pressure
Contact Area

![Bar chart showing mean contact area for TOS, SAS, and SAM. The chart indicates that TOS has the highest mean contact area, followed by SAS, and then SAM.]
Arthroscopic Transosseous Equivalent

- Many different techniques
  - Double Row fixation
  - Various Suture Patterns
Contact Area, Contact Pressure, and Pressure Patterns of the Tendon-Bone Interface

*Tuoheti* 2005

- differences among the
  - Transosseous
  - single-row suture anchor
  - double-row suture anchor techniques
Transosseous- TO

Not TOS

Tuoheti 2005

- pressure-sensitive film between the tendon and bone
Figure 2. A, schematic diagram of the single-row suture fixation technique. B, the contact area of the single-row technique (mainly located around the anchor, with no contact area observed between the 2 anchors). C, a 3-dimensional image of the contact pressure and contact area represented by different colors.
Figure 3. A, schematic diagram of the double-row suture anchor fixation technique. B, the contact area of the double-row technique (mainly located around the anchor as well as in the central area between the 4 anchors). C, a 3-dimensional image of the contact pressure and contact area represented by different colors.
Figure 2. A, schematic diagram of the single-row suture fixation technique. B, the contact area of the single-row technique (mainly located around the anchor, with no contact otherwise). C, 3-dimensional image of the
Biomechanics of transosseous-equivalent repair compared to a double-row technique

Park 2007

TOE-four suture-bridges.

TOE-two suture-bridges

Double-row rotator cuff repair technique
Need to Rehabilitate

- Early Movement
  - Passive
Methods (Haber et al)

- An I-Scan 6900 electronic pressure sensor-TekScan

Continuous recordings were made for 300 seconds.
ABDUCTION RESULTS IN PERILOUSLY LOW LEVELS OF CONTACT WITH SINGLE-ROW REPAIRS
Conclusions

- Basic Principles of Anatomy, Tissue Healing & Biomechanics still apply to techniques for Rotator Cuff Repair
- Small/Medium Tears do very well with Arthroscopic Repair
  - Surgeons must understand
    - Properties of anchors
    - Biomechanics of cuff function
    - Appropriate rehabilitation protocols
Thankyou