IC59-R: A Practical Approach to Total Wrist Arthroplasty

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Session Handouts

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A Practical Approach to Total Wrist Arthroplasty
Clinical Indications and Outcomes for TWA

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Oslo University Hospital
Norway

Consulting Fees: Swemac Orthopedics

Structure
- The surgeon
  - Background
  - Experience
- The patient
- Indication
- Surgery
- Follow-up/Outcome
- Managing problems/complications
The surgeon

- Relatively complicated surgery
  - Technically demanding
- Familiar with
  - Wrist/carpal bone surgery
  - Implants/arthroplasties
- Not afraid of using a fluoroscope (implant position is key to initial success)

The surgeon

- Gain arthroplasty experience
  - Textbooks (ie Greens)
  - Technical surgery papers (published for most of the arthroplasties)
  - Publications from the manufacturers
  - Not too late to learn order of surgery/sizematching etc during implantation
- Complete a cadaver course
  - Company-run or independent
  - Hands on
- Visit experienced colleague/attend live surgery

The patient (measuring the light)

- Motivated, compliant
  - Arthroplasty active as compared to arthrodesis passive
- Subjective
  - Pain (not too much, nor too little...)
  - Use light paretectrics/brace
  - Opiate use relative contraindication
- PROMS (VAS/QDASH/PRWHE)
  - 25-80
  - 100 (>100) can’t be explained by arthrosis...
The patient (choosing the right)

- Objectively
  - Reduced AROM
  - Flex/ext/ulnar-rad deviation (45-50%)
  - Reduced grip-strength (60%)

Indication

- All patients eligible for total wrist arthrodesis
  - Offered arthroplasty (90-95%)
    - 2/3 men, 52 years
- Exceptions/contraindications
  - Neuro-muscular disorders
  - Fixed malpositions
  - (non-compliant pts)
- Nor Arthroplasty or Arthrodesis are «final surgery»
  - (at least for younger, > 60 years)

Radiology

- Radiographs (both sides)
- Always CT
  - Reveals more extensive arthrosis
  - Excluded treated arthrodesis/resections
  - Radiolunate facet
- Mainly operate
  - SNAC/SILAC (60%)
  - Lunette malacia/Sequelea distal radius fracture (25%)
Surgery, our experience

• Since 2006

• 2 wrist arthroplasties
  - Motec®, Swenom Orthopedics, Sweden (120-130)
    - Uncemented (Ti6Al4V), ball-and-socket (MoM, Mo-PEEK, Mo-UHMWP)
  - Remotion®, Stryker (Small Bone Innovation), USA (40)
    - Uncemented (Cr-Co-V titanium spray), ovoid Mo-UHMWP, Cr-Co-V screws

Surgery main focus, reducing complications

• Infection prophylaxis!
  - LAI washer
  - AB 24 h (sensitive for staph epider/propio acnes)
  - Complete arthroplasty gown
  - Iodine-drape/glove
  - (limit traffic in operating theatre during surgery)

• Bone fixation!
  - Loosening starts the day after fixation
    - "The more the merrier"
      - Either template (we newer do)
      - Measure (fluoroscope) maximum (distal) component
  
  - "Bone friendly metal"
    - Preferably titanium alloy, at least titanium plasma spray
Surgery

- Tension (adjusting components/articulation height)
  - Not too tight
  - Test intraoperatively
  - Floppy wrist? (not a problem)

- Closure (capsule, retinaculum, subcutis, skin) as many layers as possible

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Surgery

- DRUJ?
  - Pain?
  - Never too late for Dynamic/hemiarthroplasty...
  - 1/3 had DRUJ arthritis at surgery, 1/2 at follow-up
  - 15% DRUJ surgery (Darrachs)

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Follow-up

- Clinical assessment (1 year)
  - PROMS/AROM/Strength

- Radiographs
  - Osseointegrated?
    - No implant motion (absent on repeat radiograph)
    - PU every 2-4 years
  - Fixation uncertain/other problems?
    - 6-12 months new radiograph (no restrictions for the patient)
What to expect

• The bright side
  • Pain reduction (VAS from 70 to 30)
  • Increased function (QoL/QWHE from 50 to 25)
  • Increased ADL (60% opposite side)
  • Increased grip strength (75% opposite side)
  • Satisfied patients

• The Dark side
  • Revisions (in 10 years, 20%)
  • Loosening (15%)
  • Luxation (no revisions)
  • Pain/fixed malpositions (5%)

What to expect

• The Dark side
  • Revisions (in 10 years, 20%)
  • Offer surgery for all with symptoms
    • Revision arthroplasty
      • For loosening
    • Arthrodesis
      • Pain/dislocation/infection

What to expect
Summary

- Modern wrist arthroplasty surgery
  - Complicated
  - Learning curve
  - Probably not final surgery for all (if you operate the young)

- But in most patients
  - Long term osseointegration
  - Good function (majority > 110°)
  - Good pain relief
  - High satisfaction
  - (Good alternative to arthrodesis)

Thank you, and welcome to Norway
(Hope to see you "in persona" at the next ASSH meeting)
Wrist hemiarthroplasty is not FDA approved for use in the United States.
Objectives

• Review design history
• How design may have contributed to failures
• Lack of FDA standards for testing
• Fixation issues
• Biomechanical factors
• Kinematic issues

TWA historically reserved for low demand patients

Enthusiasm tempered by 50% revision rate in RA patients
- Ward, C.M. JBJS 2011

History of total wrist arthroplasty

Generation 0

• Gluck, 1890 Germany
• First recorded wrist arthroplasty
• Ivory ball and socket
• Two fixation pegs in metacarpals, two in radius
• Good pain relief, but developed draining TB fistula

Ritt, M. et al., JHS(6) 1994
Biocompatibility Issues

- Just over half lasted more than 2.5 years
- Excessive motion?
- Particulate debris, cystic change, immune response

History of total wrist arthroplasty

1st generation
Hinged, silicone

2nd generation
Fixed COR

Kinematic Issues

- Motion not physiologic
- Fixed COR stresses fixation
- Mobile COR in normal wrist

Kinematics

- Motion not physiologic
- Fixed COR stresses fixation
- Mobile COR in normal wrist
- No offset between stems of middle metacarpal & radius

Great concept, but still not physiologic.
1st generation
- Addition of porous coating
- Screw fixation distal component
- Toroid, conoid & ellipsoid articulations

2nd generation
- Hinged, silicone
- Fixed COR

Modes of failure: 3rd Generation
- Carpal stem loosening, dorsal perforation
- Instability, dislocation
- Designed to provide flexion and extension

- 2003-2018, 20 studies
- Carpal component loosening
- Dorsal metacarpal perforation
- 17% revision rate for earliest designs
- Dislocation nearly eliminated with advent of DMARD’s in 2000
History of total wrist arthroplasty

1st generation
Hinged, silicone

2nd generation
Fixed COR

3rd generation
Ellipsoid, non-cemented, screw fixation

4th generation
New bearing surfaces, hemi-arthroplasties, mid-carpal, non-ellipsoid designs

Outcomes continue to improve

<table>
<thead>
<tr>
<th>Prosthesis</th>
<th>Author, Year</th>
<th>n</th>
<th>Arg (°)</th>
<th>OA</th>
<th>F/E arc</th>
<th>Survival</th>
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</thead>
<tbody>
<tr>
<td>Maestro</td>
<td>Nydick, 2012</td>
<td>23</td>
<td>2.2</td>
<td>74</td>
<td>90</td>
<td>96%</td>
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<tr>
<td>Re-Motion</td>
<td>Herzberg, 2012</td>
<td>215</td>
<td>4.6</td>
<td>45</td>
<td>67</td>
<td>92%</td>
</tr>
<tr>
<td>Universal II</td>
<td>Morapudi, 2012</td>
<td>21</td>
<td>3.1</td>
<td>10</td>
<td>53</td>
<td>91%</td>
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<tr>
<td>Re-Motion</td>
<td>Boeckstyns, 2013</td>
<td>35</td>
<td>3.3</td>
<td>100</td>
<td>67</td>
<td>92%</td>
</tr>
<tr>
<td>Universal II</td>
<td>Badge, 2016</td>
<td>85</td>
<td>4.5</td>
<td>0</td>
<td>50</td>
<td>91%</td>
</tr>
<tr>
<td>Universal II</td>
<td>Kennedy, 2016</td>
<td>48</td>
<td>7.0</td>
<td>29</td>
<td>57</td>
<td>80%</td>
</tr>
</tbody>
</table>
Pre-operative ROM Predicts Post-operative ROM

- Herzberg, 2012
- Boeckstyns, 2014
- Cooney, 2012

Complications

<table>
<thead>
<tr>
<th>Prosthesis Author, Year</th>
<th>n</th>
<th>Avg. (°)</th>
<th>% DA</th>
<th>COMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maestro Nylick, 2012</td>
<td>23</td>
<td>2.2</td>
<td>74</td>
<td>30% infection, instability, contracture</td>
</tr>
<tr>
<td>Re-Motion Herzberg 2012</td>
<td>215</td>
<td>4.0</td>
<td>40</td>
<td>28% loosening, 5% revision</td>
</tr>
<tr>
<td>Universal II Monopodi, 2012</td>
<td>21</td>
<td>3.1</td>
<td>10</td>
<td>42% no instability or revision</td>
</tr>
<tr>
<td>Re-Motion Boeckstyns 2013</td>
<td>35</td>
<td>3.3</td>
<td>100</td>
<td>22%</td>
</tr>
<tr>
<td>Universal II Badge, 2018</td>
<td>85</td>
<td>4.5</td>
<td>0</td>
<td>3% fusion, 3% revision, re-operation</td>
</tr>
<tr>
<td>Universal II Kennedy, 2018</td>
<td>48</td>
<td>7.0</td>
<td>29</td>
<td>27%, 11% revision, 5% CTR, 50% radiographic loosening</td>
</tr>
</tbody>
</table>

Total wrist arthroplasty: a systematic review of the evidence from the last 5 years

D. Yeoh and L. Tournet

2015
### Complications

#### Generation 3 Designs

**Periprosthetic Osteolysis after Total Wrist Arthroplasty**

- 23/44 periprosthetic loosening
- 16 radial component, 7 carpal
- Most stabilized at 1-3y
- “Close observation warranted”

**Acute carpal tunnel secondary to metallosis after total wrist arthroplasty**

- Case report: 37yo RA female
- 6 y post Universal II, new onset CTS
- “Polarizable” foreign and proliferative synovitis excised
What are the Challenges Ahead?

- **Stability:**
  - Dislocation has nearly been eliminated

- **Biocompatibility**
  - Is particulate debris a concern?

- **Component fixation**
  - Should we improve 3rd metacarpal fixation?

- **Kinematics/kinetics:**
  - Can design enhancements decrease stress on the interface?
  - No published FDA standards for testing components
  - Implant design is not based on kinematic analysis
  - No validated technique to study components *in vivo*

Future Implant Design: *In Vivo Kinematic Analysis*

- TWA design has been empiric to date
- Kinematic datasets available for THR, TKR to aid in design
- Mimicking normal kinematics and kinetics will reduce loosening and implant wear

In-Vivo TWA Kinematics

Biplanar Videoradiography (BVR)

- Two calibrated X-ray sources
- Track bones/implants

Accuracy studies – TWA

- ± 2 deg rotation
- ± 1 mm translation
Create Bone/Implant Models
1. 3D Models from high resolution CT scans
2. Create Digitally Reconstructed Radiographs (DRR’s)
3. Determine best match (optimization)
4. 3D digital registration/transformation

Experiment Design – BVR Setup

Preliminary Study: Method for Tracking TWA in BVR
Pilot Study – Flexion/Extension Task

Why is this important?

• In vivo dataset of kinematic performance
• Correlation with outcomes and complications
• Improved understanding of the relationship of design, function and longevity
• Attempt to emulate normal wrist kinematics by data-driven design

• Six patients with a generation 3 prosthesis
• Five active motion tasks: FE, RUD, DTM
• 15-20 mm proximal ↔ distal travel of COR
• Hypermobile COR may cause abnormal forces at interface, component liftoff
COR: radiocarpal arthroplasty vs midcarpal arthroplasty

Current designs limit coupled motions

Why not Preserve the Midcarpal Joint in Wrist Arthroplasty?

- Current TWA designs replace RC joint
- Restoration of anatomic COR and the oblique axis of the midcarpal joint should decrease stress on the distal component
COI PURPOSE METHODS RESULTS CONCLUSIONS

• 20 patients
• Age: 57y (23-74)

• Diagnoses:
  • SLAC (9)
  • Osteoarthritis (5)
  • SNAC (2)
  • Psoriatic arthritis (1)
  • Rheumatoid Arthritis (1)
  • Kienböck's disease (1)

MOTION

p < 0.05
• Improvements in all outcome parameters
• No activity restrictions
• First wrist replacement reported to improve pre-operative ROM
• Failure and complication profile comparable to other surgical options
• Conversion to total wrist arthroplasty facilitated by new modular design
RECENTLY COMPLETED MOTION ANALYSIS TRIAL

- Procedure/Instruments
- 3D motion capture
- 12 cameras, previously published marker set
- 9 patients with midcarpal hemiarthroplasty studied
- 4 tasks:
  - Circumduction (clockwise)
  - Circumduction (counterclockwise)
  - Dart throwing
  - Hammering

Summary

- WHA provided a significantly smaller circumduction envelope than healthy
- Circumduction envelope orientation was preserved by WHA
- Mean coupling axis was preserved
- WHA preserved task specific quadrants of motion for Darts and Hammering

WRIST ARTHROPLASTY: DESIGN CONSIDERATIONS

- Stability: improved
- Implant Fixation: Carpal fixation still concerning
- Biocompatibility: particulate debris?
- Kinematic analysis & design should help to:
  - Restore center of rotation
  - Improve circumduction & coupled motion
  - Diminish loosening & particulate debris
  - Increase implant longevity and function
THANK YOU!

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Mark Lenhoff, BS
...and the entire Dartthrower’s team!

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The 75th Annual Meeting of the ASSH
IC59: A Practical Approach to Total Wrist Arthroplasty
October 2, 2020

2013

80 y/o. male now 6 years post midcarpal hemiarthroplasty; plays golf several times per week

KINEMATX MIDCARPAL HEMIARTHROPLASTY

2010’ s: From bench to dartboard

WRIST HEMIARTHROPLASTY IS NOT FDA APPROVED IN THE USA.
Top Surgical Tips and Tricks for Implanting TWA

ICR 59-R: A Practical Approach to Total Wrist Arthroplasty
ASSH Annual Meeting
October 2020
Marco Rizzo, MD
Mayo Clinic
Rochester, MN

COI Statement
• No relevant conflict regarding this presentation

60 y/o male, RHD retired – left wrist pain
60M, Retired, active – right side

Treatment of right side?
- Denervation
- Fusion
- Arthroplasty

Right side – 1 year later..
Recommendations for left side?

• Denervation
• Arthrodesis
• Arthroplasty

Choices for TWA in 2020

• Universal III-Freedom (Integra)
• ReMotion (Stryker)

Tip 1: Elevate retinaculum so that you can appropriately tension the closure

My preference is to make a z-plasty within the 4th compartment
Tip 2: U-shaped capsular exposure

Leave a cuff proximally off the radius to allow for re-approximation

Tip 3 (critical): Center the alignment guide appropriately
- The lunate fossa is the key
- Confirm with fluoroscopy
- Secured with pins
- Take the time to be right on this

Tip 4: Distal cut at level of head of capitate
- Confirm that it is also parallel to the CMC joints
- Make sure your exposure is adequate
- Cut completed freehand after starting the cut with the guide
- Stay parallel to the joint in the axial plane as well
Tip 5: Center the radial alignment guide pin

- Lister’s tubercle is a good marker for center
- Dorsal 1/3 junction
- Confirm with fluoroscopy
- Drill in preparation for broaching

Tip 6: Use burr for sclerotic bone at the distal radius to help better insert the radial trial

Tip 7: Distal component guide is centered at capitate

- Ideal: Center-center
- In more deformed wrists there may be an extended position of capitate and it may require a more dorsal start point
- Confirm with fluoroscopy
Tip 8: Broach the capitate
• Ideal: Avoid crossing the CMC if possible
• May need to burr if bone sclerotic

Tip 9: Screw placements for distal component
• Drill towards the index and ring metacarpals
• OK to cross 2nd CMC
• Avoid crossing 4th CMC if possible
• Alternate tightening of screws as you place them into carpus

Tip 10: Good Fit
• When trialing, the wrist should be stable to 30-50 degrees extension, 20-40 degrees flexion and 40 degrees of radioulnar motion
• Distraction should allow ~ 2-4mm of separation
• Options for a “loose” press fit
  - Impaction cancellous bone grafting
  - Cementing
• Generous with immobilization
  - At least 2 – 4 weeks
Summary

• Total wrist arthroplasty can be a helpful intervention that alleviates pain and preserves motion in patients with end-stage wrist arthritis.
• Technically challenging
  • Especially in patients with carpal collapse and significant deformity
  • Meticulous technique will help ensure best possible outcome
Managing Complications of Failed TWA

Arnold-Peter C. Weiss, M.D.
R. Scot Sellers Scholar of Hand Surgery
Chief of Hand & Upper Extremity Surgery
Vice Chairman & Professor of Orthopaedics

Current Status

• 4th Generation implants
• Nearly always uncemented
• Low dislocation / loosening risk
• Some subsidence / radiolucent lines over time
• Use in OA cases becoming more common
Failure due to trauma / time

- Almost always need cement / cerclage wiring
- Debride synovium with particulate debris
- May need to take more radius if previously cemented
- Do a Darrach if not already performed
- Cast for 4 weeks
- Some of these may have been loosening before event
- Can always fuse wrist (use femoral head allograft)
- Cement use is more common; hybrid techniques of spot areas of cement with other areas left uncemented may be used, depending on defect sizes.
- An allograft can help, with interference fit application.
- Take out all synovial-type tissue from native bone once the implant is out. Scrape it out with a curette.
• Take out all old cement if present; avoid breaking the radius while doing this step. Use very small osteotomes and gentle hammering. Try to crack the cement and take it out piecemeal.
• If you crack the radius, use a 18- or 20-gauge cerclage wire around the radius.
• You can resect a bit of the distal radius (usually thin, poor-quality bone); it allows deeper broaching and placement of the radial component. You may need to use a burr to open the radial shaft slightly.
• Try to use a longer index metacarpal screw if possible.
• Rarely, you may need to cross the fourth or fifth CMC with a longer screw as well to get stable purchase of the carpal plate; this method can result in fifth CMC pain after surgery, so try to avoid doing so.
• Immobilize longer after surgery, usually 4 to 5 weeks.
Thank You