History of PIP and MCP joints replacement

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A. Paré resects an elbow in a 16 years old boy

Ollier, White, Syme,…describe articular resections
History of « arthroplasties »

- Hoffa (1900) performed a wrist joint resection with interposition.
- 1st world war: resection-arthroplasties were performed in fingers by Russian surgeons with interposition (quoted by Schupatschoff).
Fingers arthroplasties

1914: Payr, 2 cases in the PIP with interposition

1915: Gallagher

1920: Lexer, 1 PIP in a violinist with subcutaneous tissue interposition

1929: Mac Ausland interposed fascia lata

35 cases reported in 1954
PIP resection- arthroplasty

- Fowler (1947) reported 16 cases in 2nd world war injured patients
- Carroll (1954) reported of 30 cases
Bunnell’ closing remarks: « …there are certains requirements. There must be redundancy of dorsal skin, the surroundings part must be in good condition, the muscles must be working, the long extensor must be free from adhesions and there must be a strong flexor.. »
MP resection-arthroplasty

1940, Smith-Peterson is credited for the 1st resection-arthroplasty

Fowler (1946) and Riordan & Fowler (1947) described the double-wedge resection
MP resection-arthroplasty

1947, Kestler
1958, Kuhn

Not very popular
MP resection-arthroplasty

- 1964, Vainio, interposition of the plicated extensor tendon
- 1985 (?), Tupper, interposition of the palmar plate

See: Vainio & Tupper for more details, JHS 1989 suppl II
Resection-arthroplasties

- All were abandoned in the late 70’s-80’s with the availability of silicone implant (and new prosthesis)
- However, comparative studies failed to demonstrate their inferiority compared to silicone interposition at the MP joint level
- They are seldom used when prosthetic replacement is contra-indicated (infection,...)
First protheses

- Burman (1940) uses a Vitalium cup on a middle finger
- Gerold Klein (1958) is credited for using a prosthesis
First protheses

Brannon (1959) uses a metal then titanium prosthesis designed after wood models (2 MP & 12 PIP)
Brannon, 1959
many problems including magnetisation of the finger!
First prostheses

Flatt (1960) modifies Brannon’s design and reports of 101 cases in 1961, 242 cases in 1972
Flatt’s series

- 242 cases, 6.2 yrs FU
- 167 MP (15 withdrawn), 16° mobility
- 75 PIP (11 withdrawn), 36° mobility
Blair's series

- Blair (1984) reported of 56 Flatt’s prostheses with 11.4 years follow-up
- 25° mobility
- **However**
  - 45% extensor dislocation
  - 50% axial rotation of the finger
  - 57% recurrence of ulnar drift
  - 86% implants are loose
Other prostheses

- Steffee (1964) designed 3 successive models, of which 106 cases were reported in 1997

Mark I

Mark II

Mark III

50% complications between 2 and 10 years FU
Many models were designed in the 70’s

- Most are anecdotal only
- St Georg (11 cas)
- Schetrumpf (13 cas)
- Garcia-Moral
- Strickland
- Walker
One series (Adams, 1990) reported of hinge fracture (40%), heterotopic ossification (100%) and lucent lines (80%) with degradation of results starting in the 3rd year.
Nicolle’s design (1973)

- 101 MP joints replacement (24 pts) (Varma, JHS 91) with 40 m FU
- Flexion 30°, Ulnar deviation 27°
- 4% removed for infection
- None were fractured
Disappointing results made these prostheses to be abandoned in the 80’s

- Loosening (86%)
- Fracture of the implant (50%)
- Recurrence of deformation (swan-neck, Boutonniere, ulnar drift, ...)
- Progressive loss of mobility
- Subsidence
Constrained designs have biomechanical disadvantages. Their inherent stability increases loading on the stems with loosening and/or breakage.

**Figure 4.** Hinge joint: inherent mechanical disadvantage. (Top) The bearing’s center and contact are colinear in extension. (Bottom) The contact displaces dorsally on flexion, altering the effective moment arms of flexion and extension. Solid circles, bearing center; open circles, axle contact.
Ways of research in the 80’s

- **Silicone implants**
  - Increase bony fixation (Dacron coated), mobility (pre-flex), stability (Helal)

- **Prostheses**
  - Increase bony fixation (constrained and semi-constrained designs)
  - Improvement of design with resurfacing prosthesis
Silicone implants

- Biomeric implants broke early and are abandoned in the 70’s
- Niebauer (1965) Dacron-coated prosthesis shows no improvement compared to Swanson design
Silicone implants

Other implants were scarcely used or reported

Calnan-Reis  Calnan-Nicolle

28 cases

180 implants, 32% fractures at 1.7 yr FU
Silicone implant

- Helal 146 implants (40 pts), 1.5 yrs FU
- 1.4% fractures, 9.6% infected, 11.6% ulnar drift
- ROM: 38° (0-10-48)
Swanson (1966) is still the reference

- Available: Swanson (Wright), Soft Skeletal implant (ex-Sutter; Avanta),
- Neuflex (De Puy), Preflex (Avanta) Silicone MP (Ascension) are pre-flexed to 30°
<table>
<thead>
<tr>
<th>Author</th>
<th>n</th>
<th>implants</th>
<th>FU</th>
<th>Fx</th>
<th>ROM</th>
<th>other complication</th>
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<td>Swanson 1972</td>
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<td>5</td>
<td>0,8%</td>
<td>53°</td>
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<td>Millender 1975</td>
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<td>Maurer 1990</td>
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<td>3,2%</td>
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<td>Goldfarb 2003</td>
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<td>63%</td>
<td>36°</td>
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<tr>
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<td>Takigawa 2004</td>
<td>70</td>
<td>15</td>
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<td>30°</td>
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<td>Iselin 1995</td>
<td>120</td>
<td>5-23</td>
<td></td>
<td></td>
<td>11% infection</td>
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<tr>
<td>Lin 1995</td>
<td>69</td>
<td>3,4</td>
<td>7%</td>
<td>46°</td>
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<td>Ashworth 1997</td>
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<td>5,8</td>
<td>10%</td>
<td>29°</td>
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<td>Swanson 1985</td>
<td>424</td>
<td>5</td>
<td>5%</td>
<td>38-60°</td>
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Third generation prosthesis

Bony fixation

Resurfacing
Intra-osseous fixation

- Many models were designed with a hinge and intra-medullary stems
- With disappointing results at mid-term FU
Titanium stems

Hagert, then Lundborg reported their long-term experience with titanium stem

- Excellent bony fixation (> 90%)
- With fracture of the hinge (68%)
Titanium stems

- Moller reported the same experience at the PIP level
Resurfacing prosthesis

- Introduced by Linscheid in 1979
- Goal: To limit the constraints on the implants by transferring the loads to the soft-tissues (ligaments and tendons)
- Pre-requisite: “Normal” tendons and intact ligaments
First series

- 70% survival rate at 16 yrs
- 32 good, 19 average and 15 poor results at 4.5 yrs FU
- ROM 47° (0-14-61)
Biomechanical limits

Motion depends on the exact replication of the center of rotation (positioning) in both planes.

Figure 5. A change in the radius of curvature of the joint can alter the effective length of the tendons. In a semicircular joint configuration, the tendon will displace the length of the radius of curvature in 1 radian of angular displacement (57°). If the radius of curvature is decreased, the tendon is effectively lengthened; this results in an extension lag. θ = d arc/r.
This is particularly true at the MP level whose anatomy is very different from the PIP joint.

**Figure 6.** Sagittal moment arms. (A) Normal, correct placement prosthesis. (B) Dorsal displacement results in flexion stance; palmar displacement results in extension stance.

**Figure 7.** Coronal moment arms. (Left) Normal. (Center) The position of the prosthesis maintains correct moment arms. (Right) Radial displacement of the prosthesis results in unbalanced moment arms and ulnar deviation.
Resurfacing prosthesis

- Ascension (pyrocarbone)
- SBI (Avanta)

Some warnings:
- No bony fixation of the pyrocarbone implants
- Huge constraints on the spongy bone
- Squeaking of the prosthesis,..
Pyrocarbone series

Stutz, 13 cases, 1 yr FU, good results

Tuttle, 18 cases, 13 m FU. All improved (2 loosening, 1 Fx, 8 noisy prosthesis,)

Schultz, 20 cases, 0,5-2 yrs FU, minor radiological signs

Herren, 17 cases, 20 m FU, 8 loosening !, 3 lucent lines

Bravo, 50 cases, > 2yrs FU, mobility 40  47°, pinch 3  4 kg, grasp 19  25 kg, Pain 6,3  1,2/10

28% secondary surgery, 8% revision rate
Can we combine the two axles of research?

- Condamine (1985) introduce the press-fit concept of a poliethylene stem.
- Dias reported interesting results with 5 yrs FU for a MP prosthesis combining stem fixation and resurfacing design.
**Conclusion 1**

We must split between MP and PIP prosthesis whose anatomy, physiology, surgical approach and indications are very different.

<table>
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<th>MP</th>
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<th>3</th>
<th>Total</th>
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<tr>
<td>Swanson</td>
<td>1777</td>
<td>625 Avanta</td>
<td>219 Neuflex</td>
<td>2651</td>
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<tr>
<td>IPP</td>
<td>2</td>
<td>10 Ascension</td>
<td>9 Avanta</td>
<td>57</td>
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<tr>
<td>Swanson</td>
<td>22</td>
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</table>
Conclusion 2

**PIP:** bi-condylar joint, one single axis of rotation, stability due to ligaments, presence of the central extensor slip.

**MP:** Hemispherical in its dorsal part, bi-condylar in its ventral part. Asymmetrical, different from fingers to fingers, 2 main axles of motion.
Swanson’s design, which is very tolerant and easy to change is still the reference, even with its numerous complications.

New models have to prove their tolerance but also their ability to maintain or improved motion and their durability.