History of PIP and MCP joints replacement

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History of « arthroplasties »

- 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 sub-cutaneous tissue interposition
- 1929: Mac Ausland interposed fascia lata

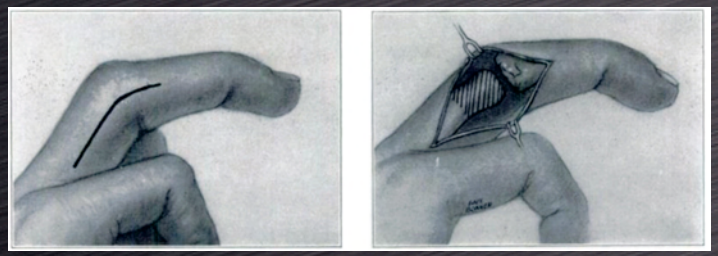
- 35 cases reported in 1954

PIP resection- arthroplasty

- Fowler (1947) reported 16 cases in 2nd world war injured patients
- Carroll (1954) reported of 30 cases

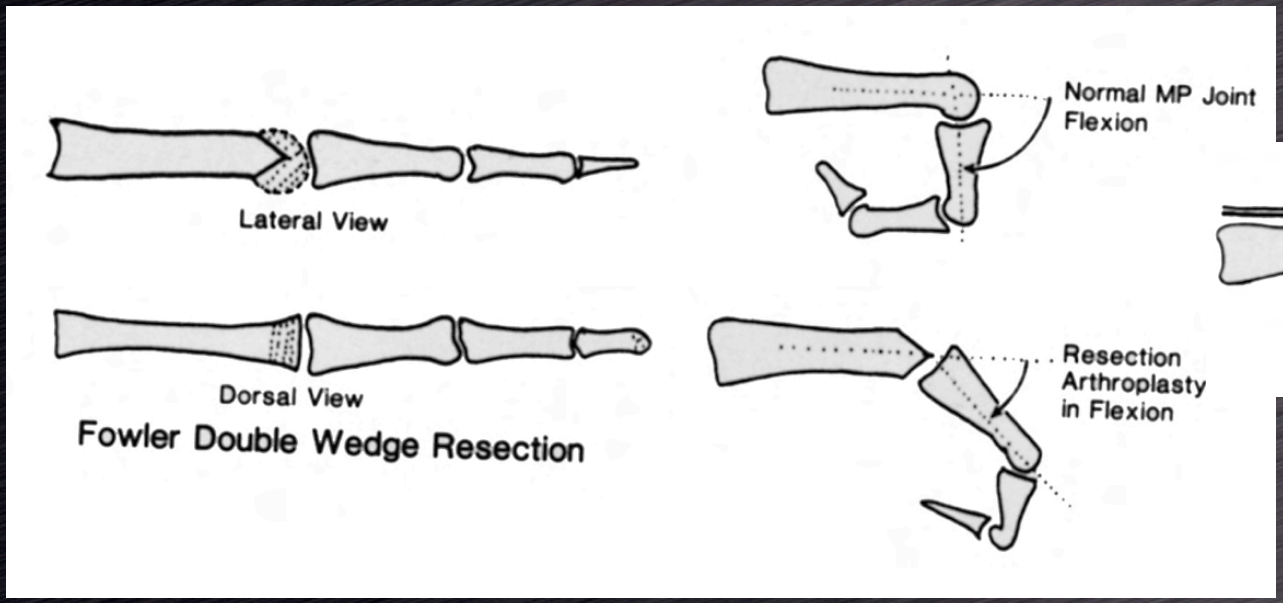
PIP resection- arthroplasty

- 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

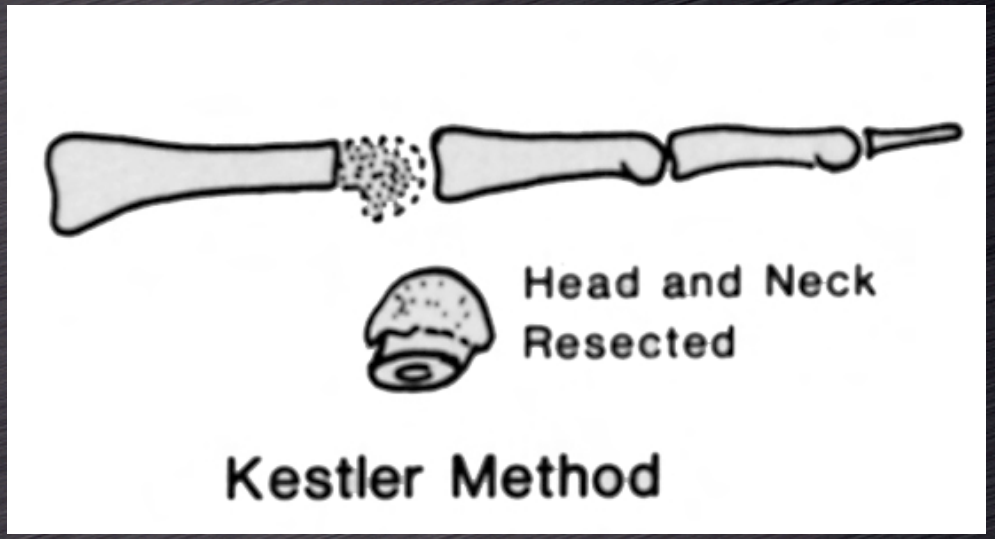
- 1940, Smith-Peterson is credited for the 1st resection-arthroplasty
- Fowler (1946) and Riordan & Fowler (1947) described the double-wedge resection

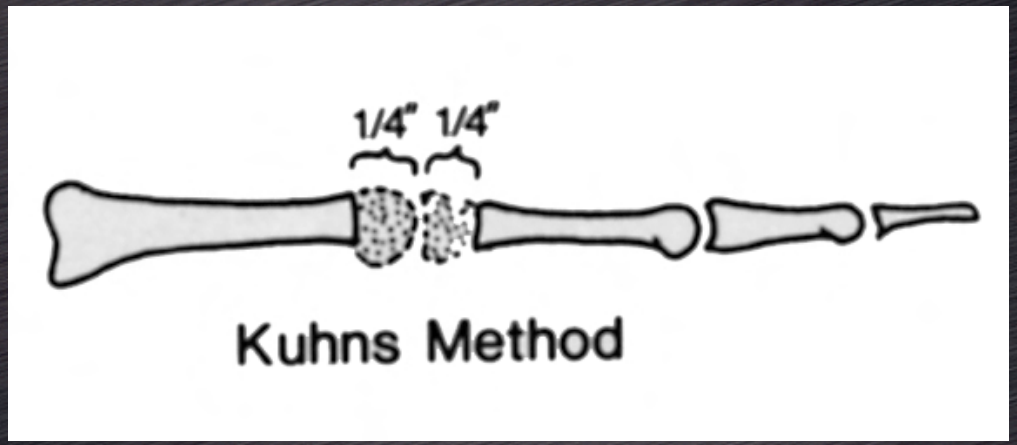


MP resection-arthroplasty

- 1947, Kestler
- 1958, Kuhn

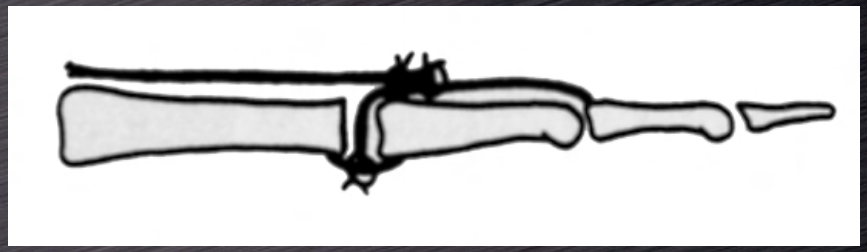
Not very popular

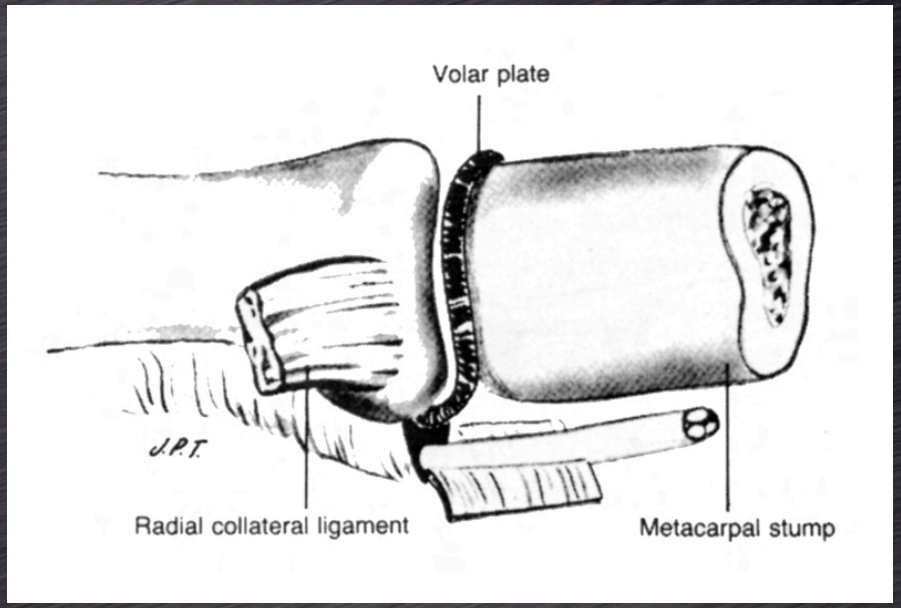




MP resection-arthroplasty

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





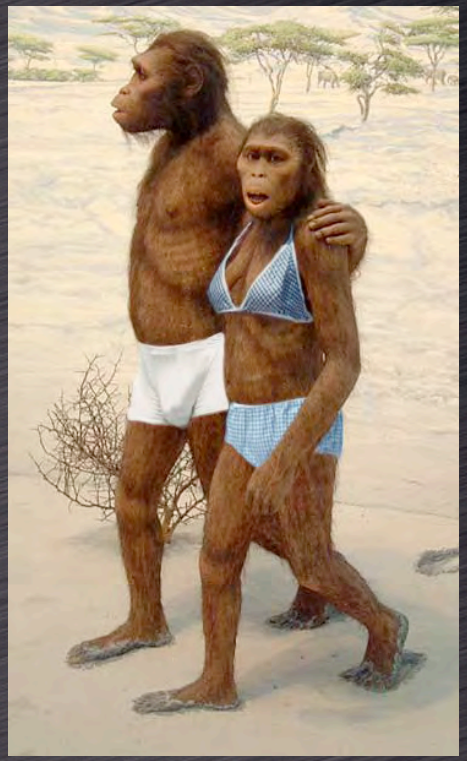
See: Vainio & Tupper for more details, JHS 1989 suppl II

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,...)

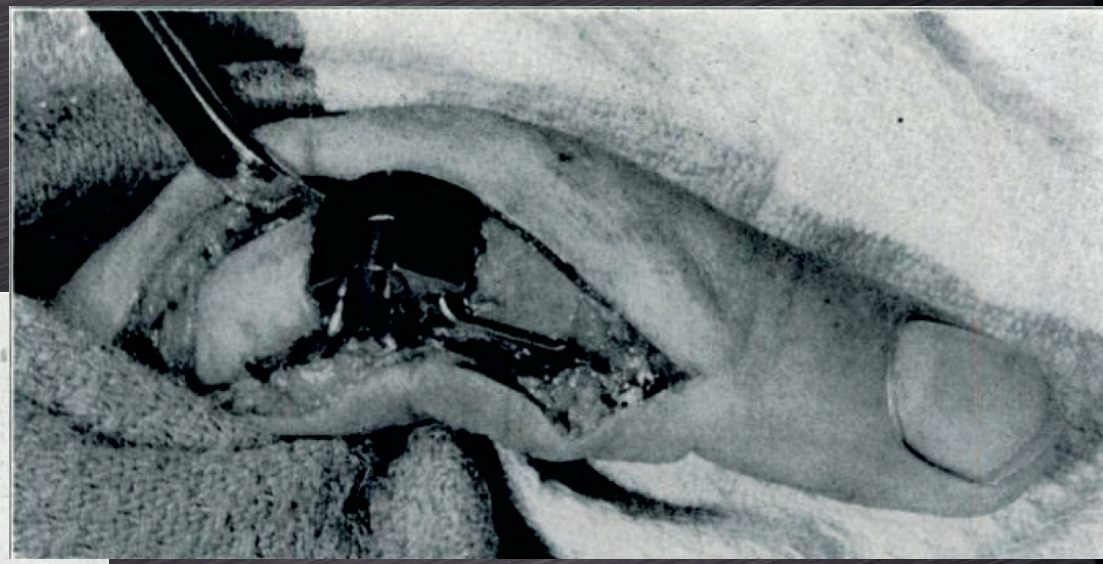
First protheses

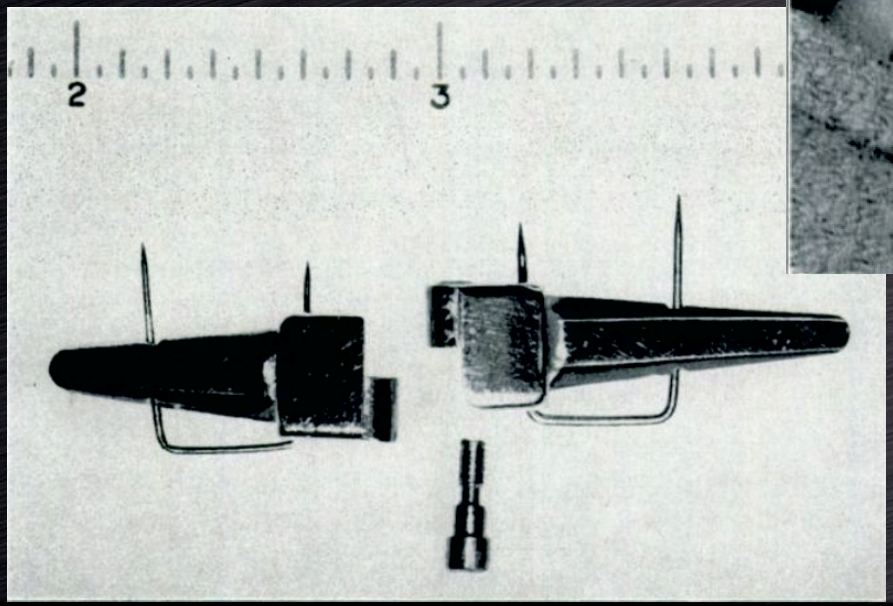
- Burman (1940) uses a Vitalium cup on a middle finger
- Gerold Klein (1958) is credited for using a prosthesis

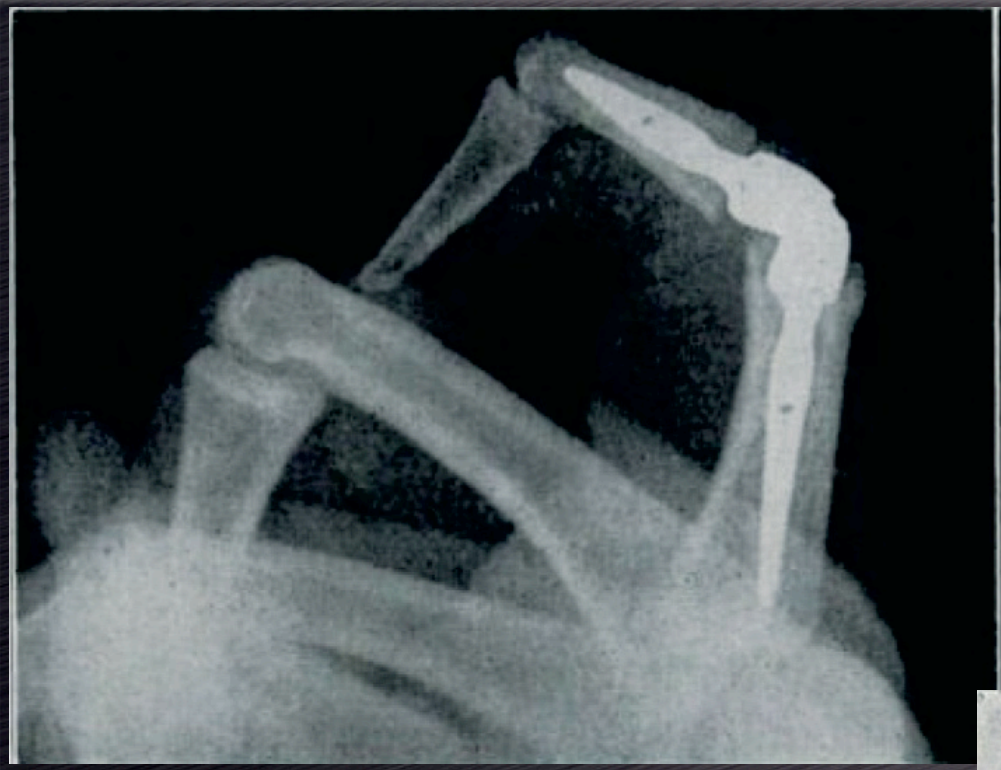


First protheses

- Brannon (1959) uses a metal then titanium prosthesis designed after wood models (2 MP & 12 PIP



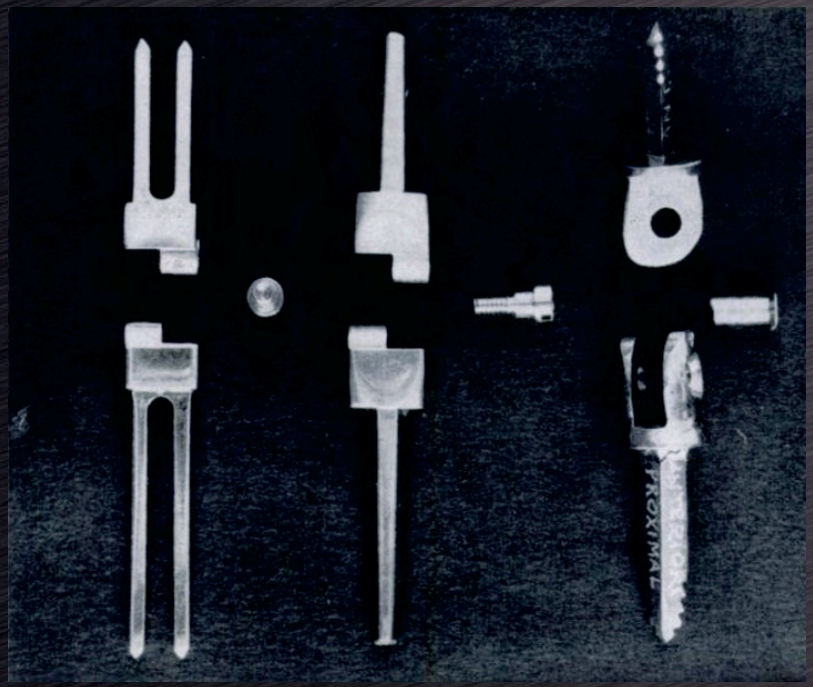


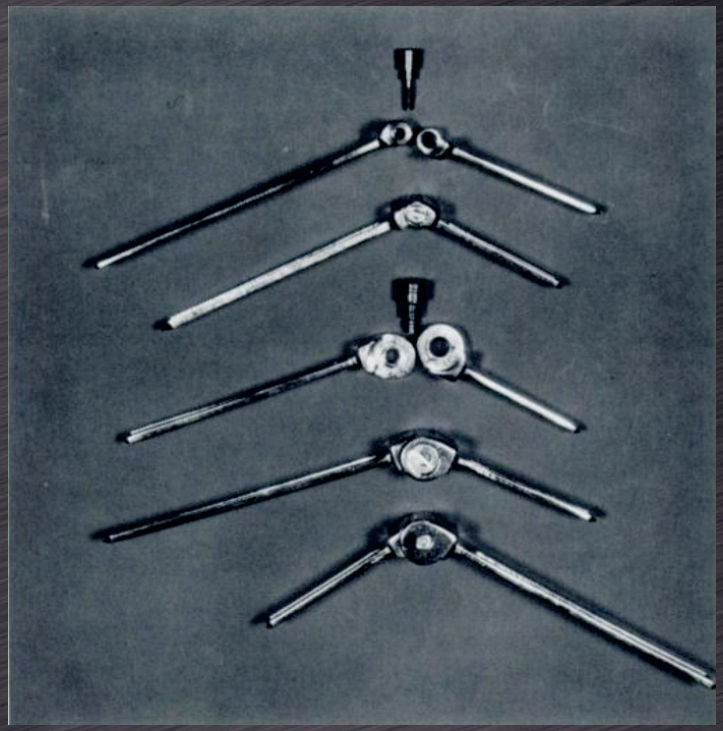


Brannon, 1959
many problems including
magnetisation of the finger !

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

Flatt - Brannon - Richards

Blairs' 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 drit
  - 86% implants are loose

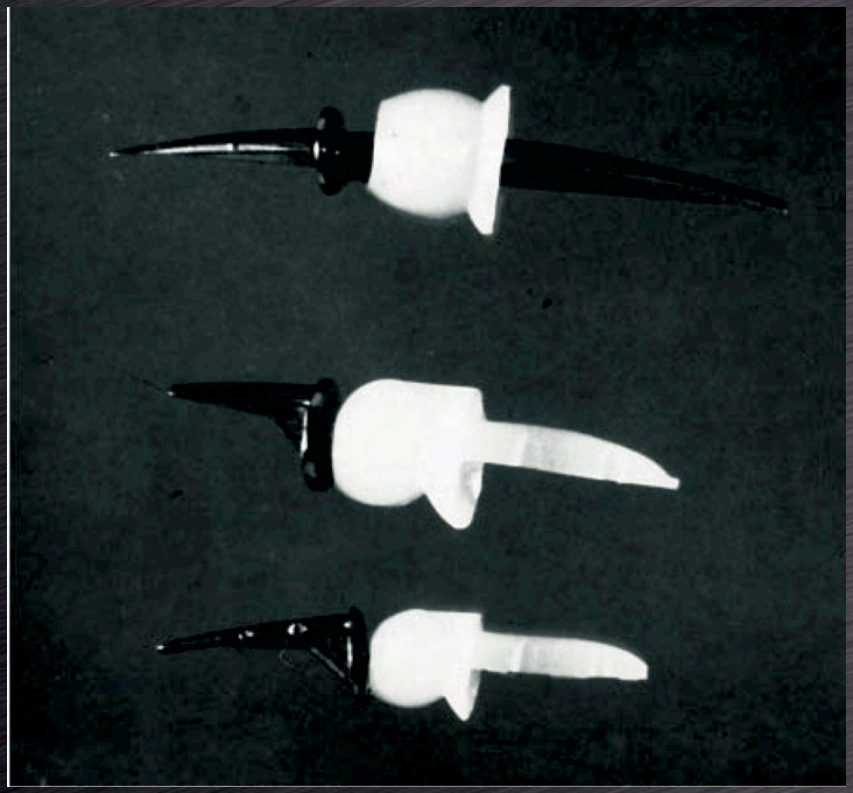
Other prostheses

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

Mark I

Mark II

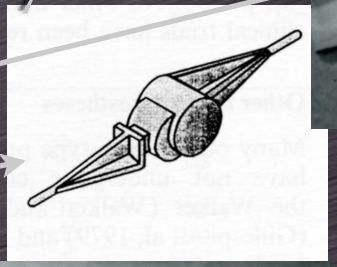
Mark III



50% complications between 2 and 10 years FU

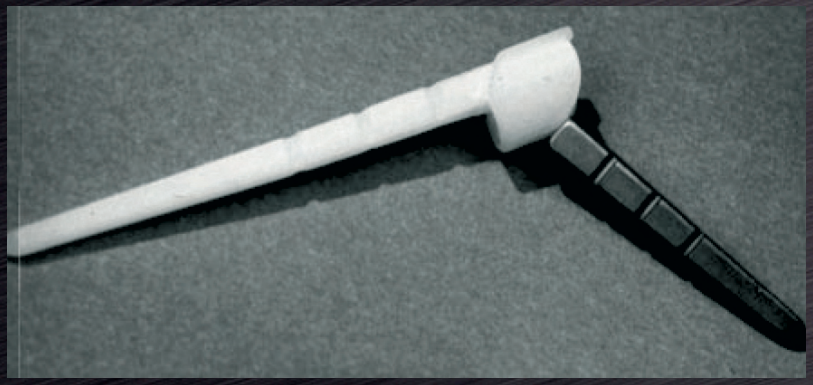
Many models were designed in the 70's

- Most are anecdotical only
  - St Georg (11 cas)
  - Schetrumpf (13 cas)
  - Garcia- Moral
  - Strickland
  - Walker



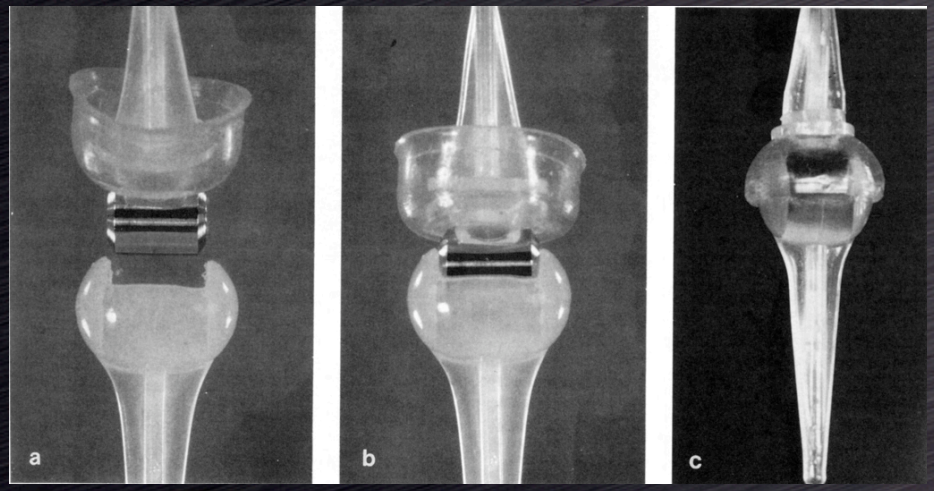
Schulz's design

- 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

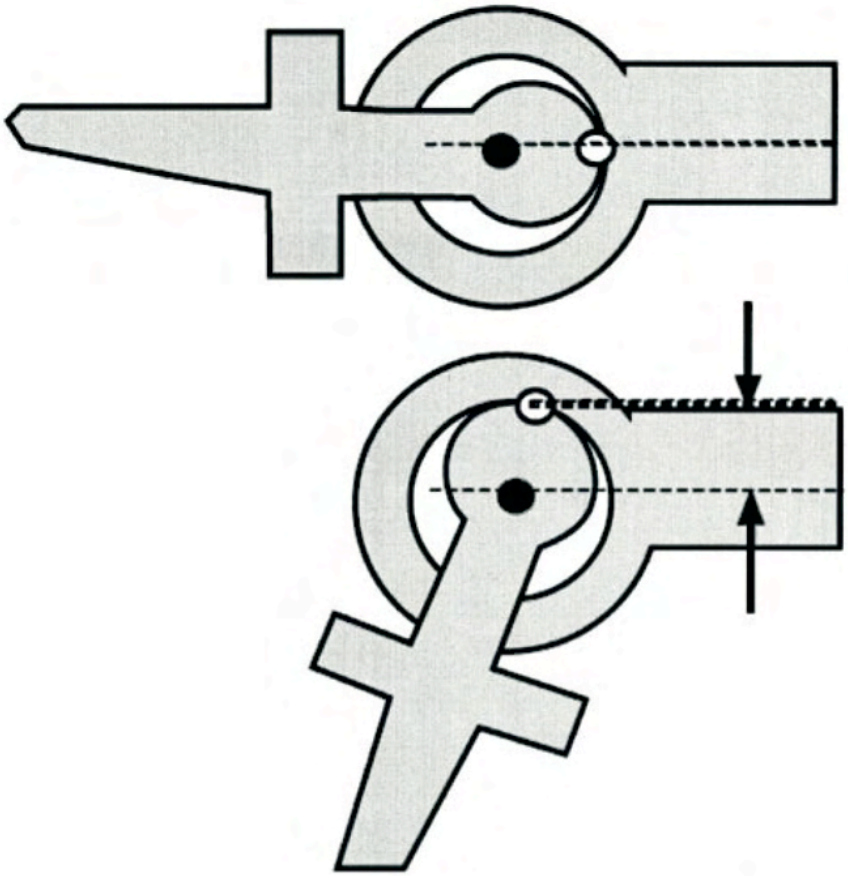
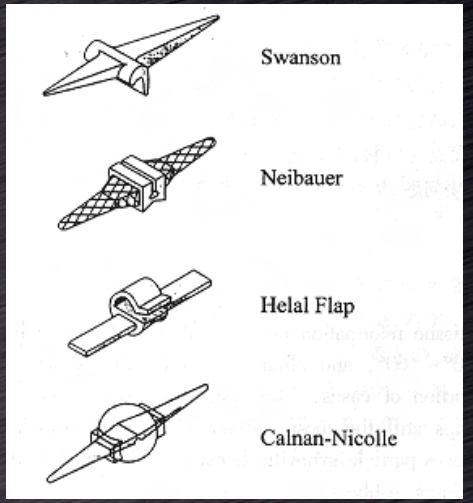
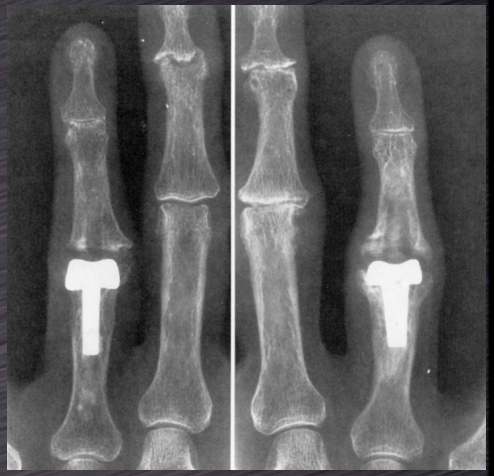


Figure 4. Hinge joint: inherent mechanical disadvantage. (Top) The bearing's center and contact are colinear in extension. (Bottom) The contact displaces dorsally on flexion, altering the effective moment arms of flexion and extension. Solid circles, bearing center; open circles, axle contact.

Ways of research in the 80's

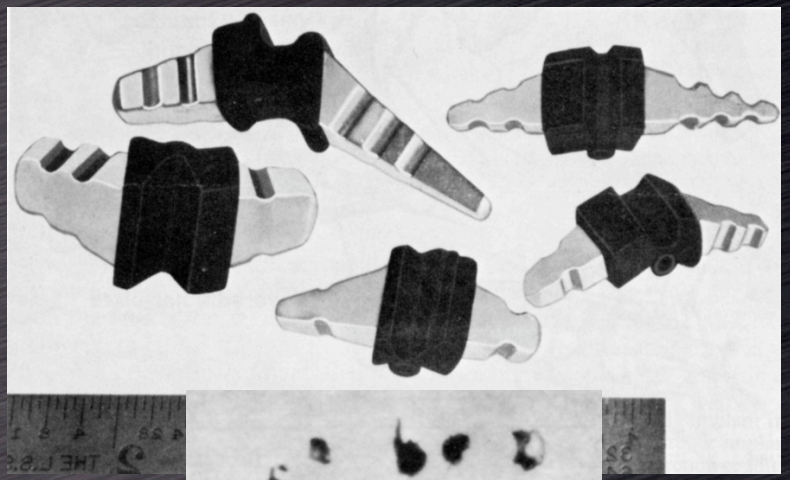
- **Silicone implants**
  - Increase bony fixation (Dacron coated), mobility (pre-flex), stability (Helal)
- **Prostheses**
  - Increase bony fixation (constrained and semi-constrained designs)
  - Improvement of design with resurfacing prosthesis

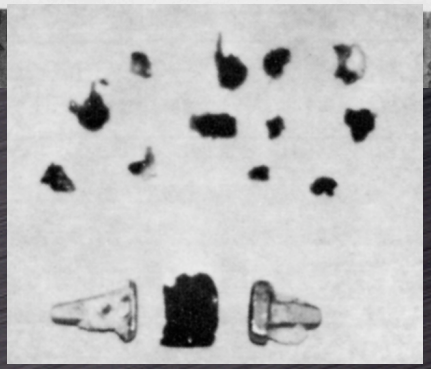


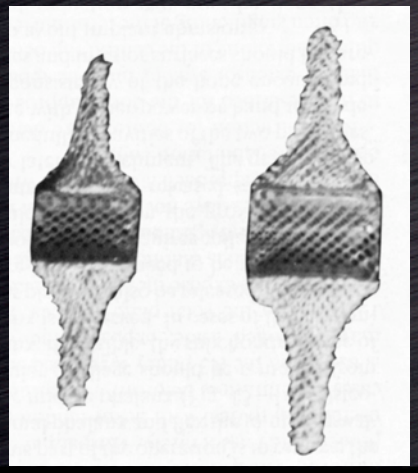


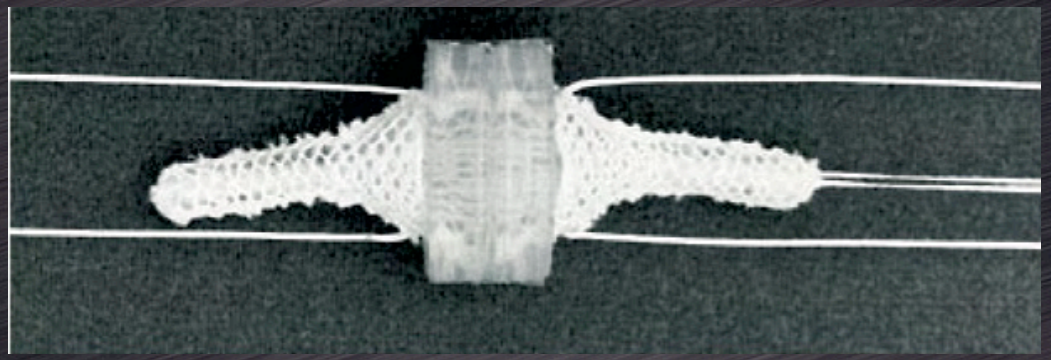
Silicone implants

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



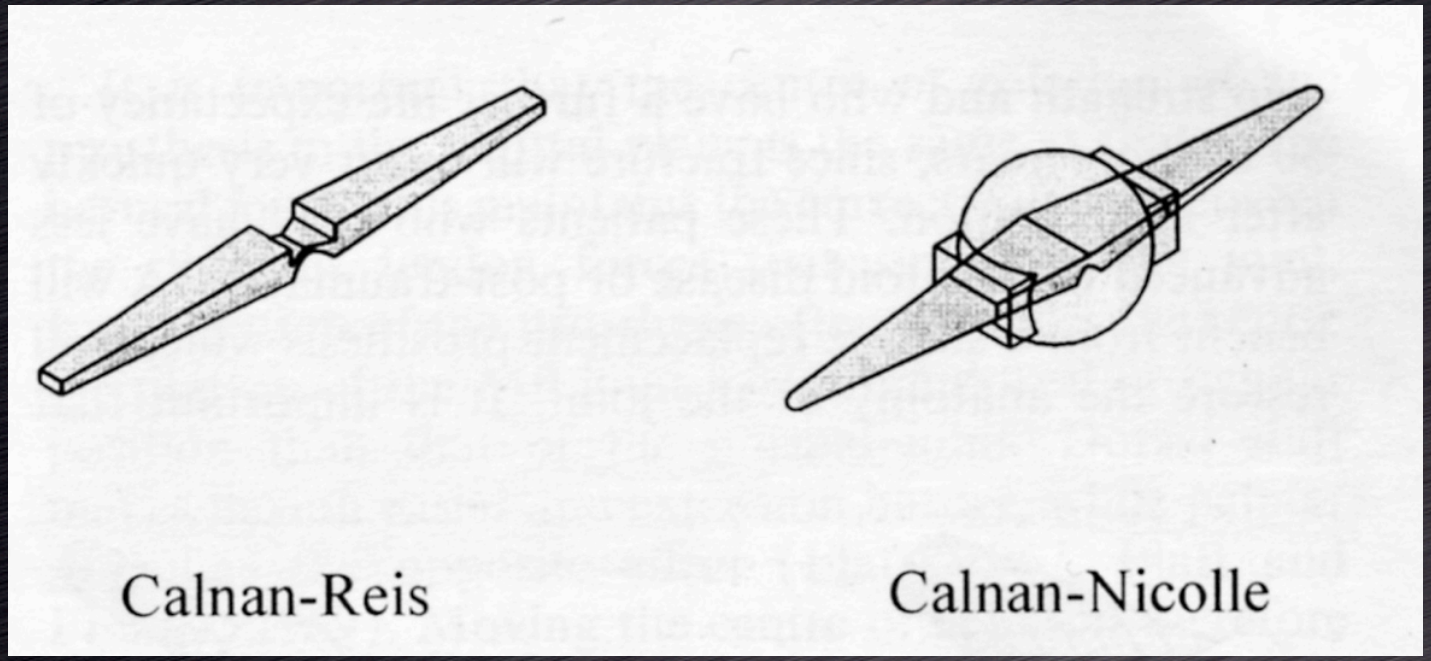






Silicone implants

- Other implants were scarcely used or reported

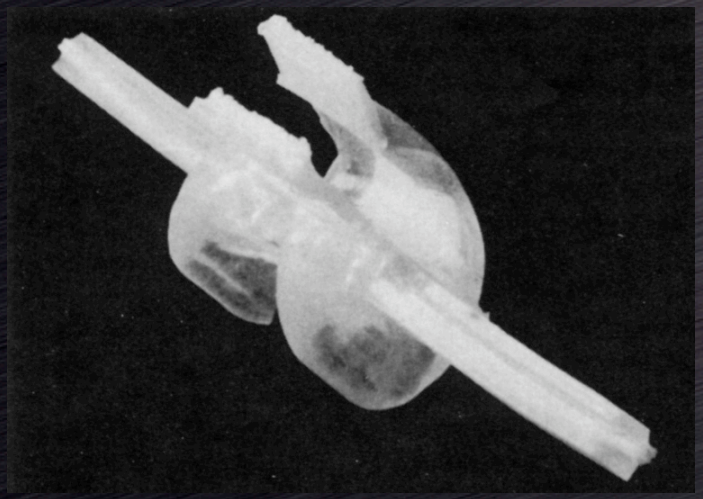


28 cases

180 implants, 32% fractures at 1,7 yr FU

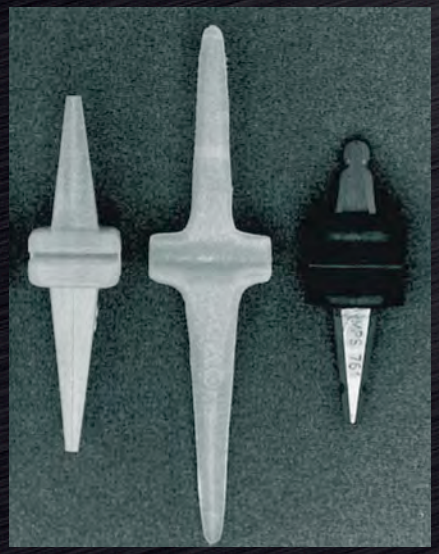
Silicone implant

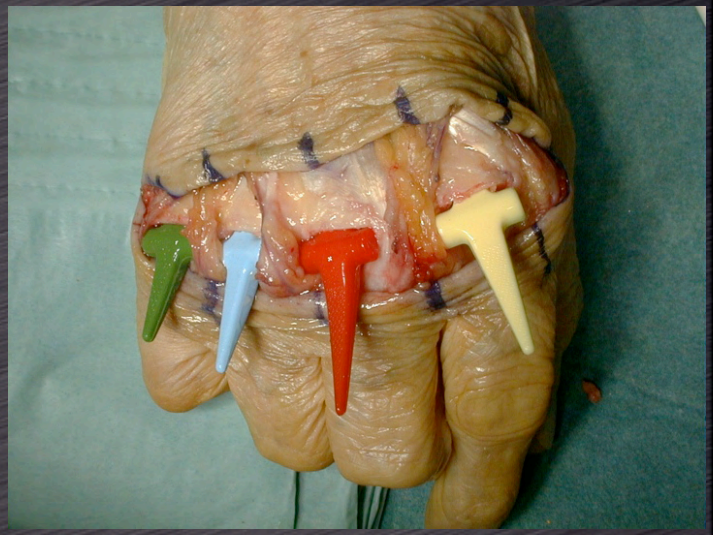
- Helal 146 implants (40 pts), 1,5 yrs FU
- 1,4 % fractures, 9,6 % infected, 11,6 ulnar drift
- ROM: 38° (0-10-48)



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°





MP joints, Swanson results

Author	n	implants	FU	Fx	ROM	other complication
Swanson 1972		3409	5	0,8%	53°	3%
Millender 1975	631	2105				0,4%
Maurer 1990	105	446	8,9	8%	48°	16%
Wilson 1993	77	375	9,6	3,2%	29°	45%
Kirschenbaum 1993	27	144	8,5	10,4%	43°	
Goldfarb 2003	36	208	14	63%	36°	

PIP joints, Swanson results

Author	implants	FU	Fx	ROM	other complication
Takigawa 2004	70	15	15%	30°	30%
Iselin 1995	120	5-23			11% infection
Lin 1995	69	3,4	7%	46°	18%
Ashworth 1997	99	5,8	10%	29°	
Swanson 1985	424	5	5%	38-60°	14%

Third generation prosthesis

Bony fixation
Resurfacing

Intra-osseous fixation

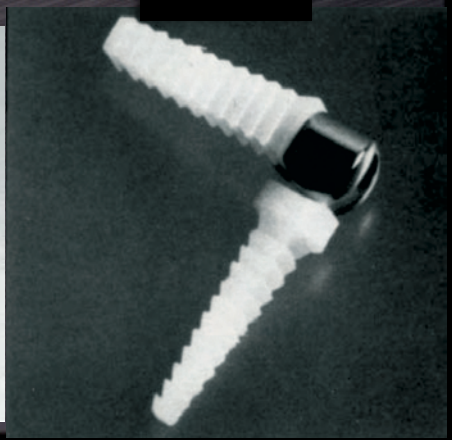
- Many models were designed with a hinge and intra-medullary stems
- With disappointing results at mid-term FU

Digitos

Digital

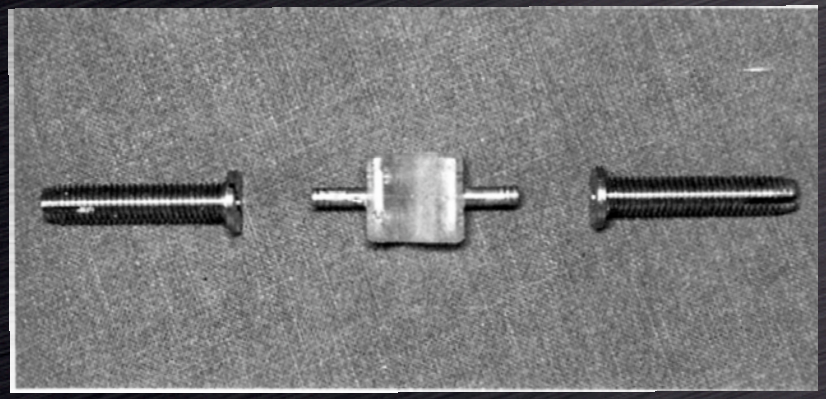
WEKO

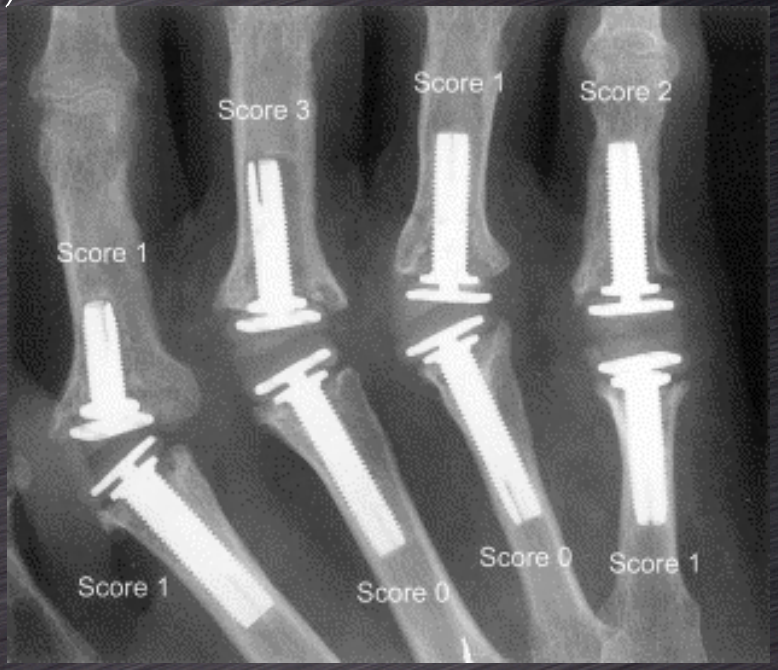
Saffar

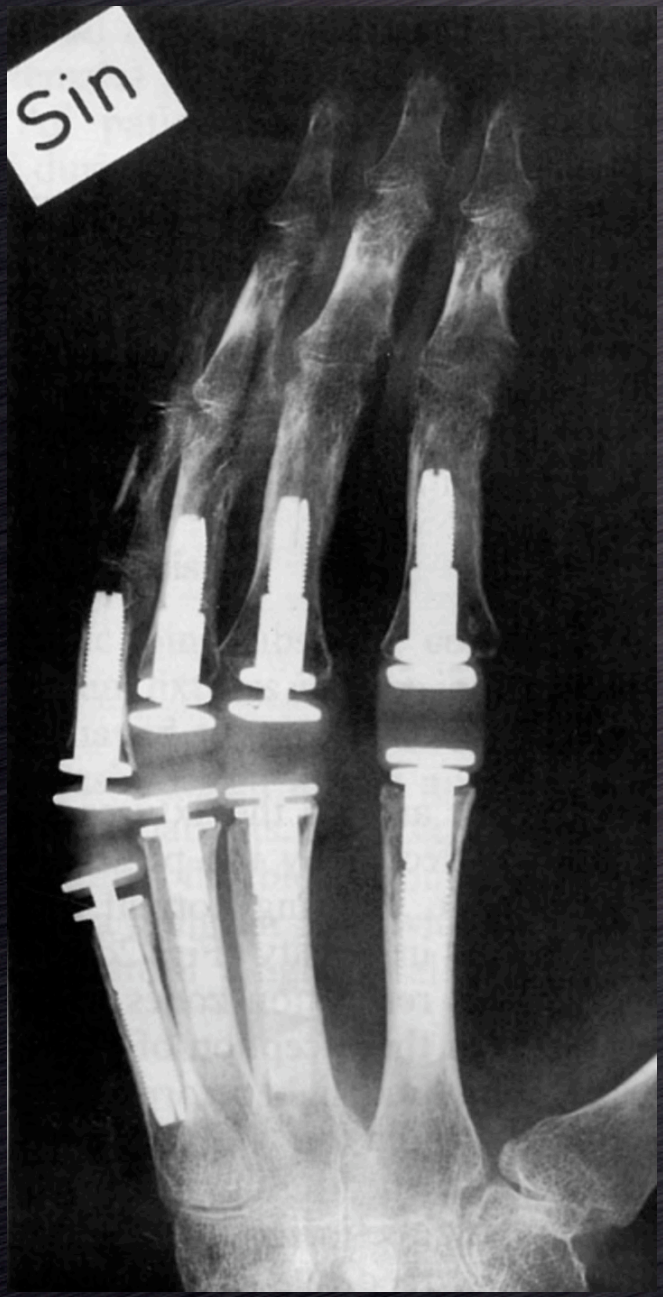


Titanium stems

- Hagert, then Lundborg reported their long-term experience with titanium stem
  - Excellent bony fixation (> 90%)
  - With fracture of the hinge (68%)



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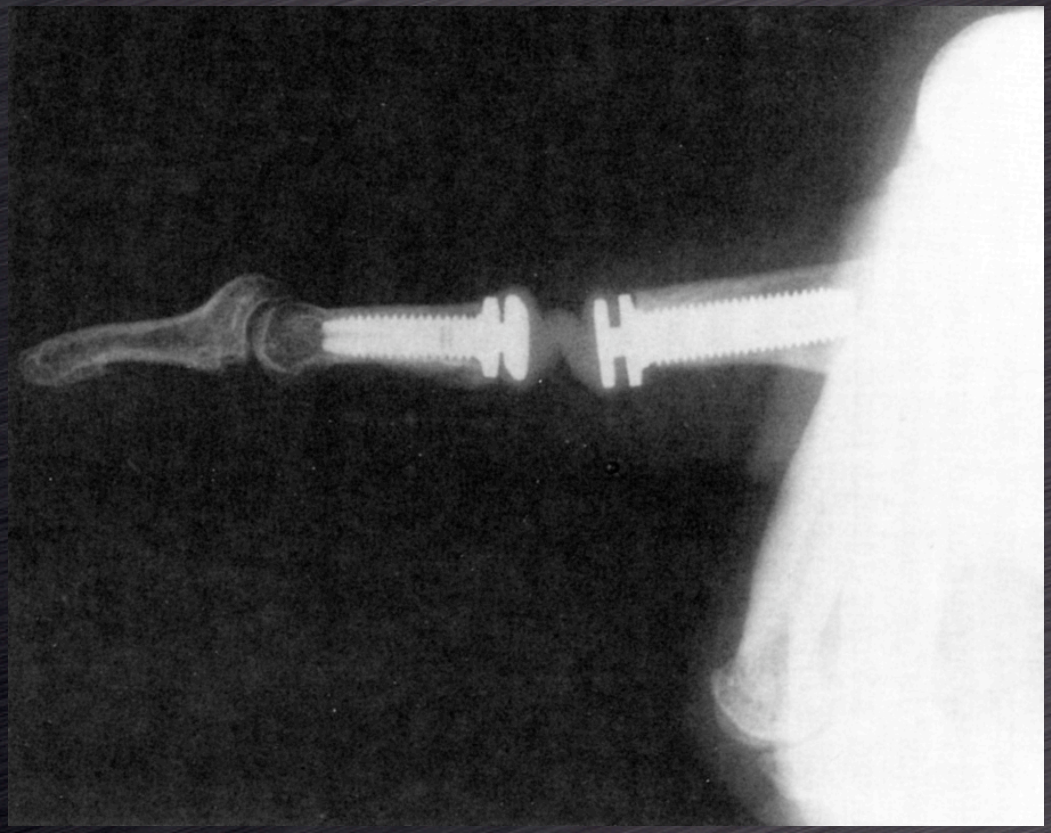
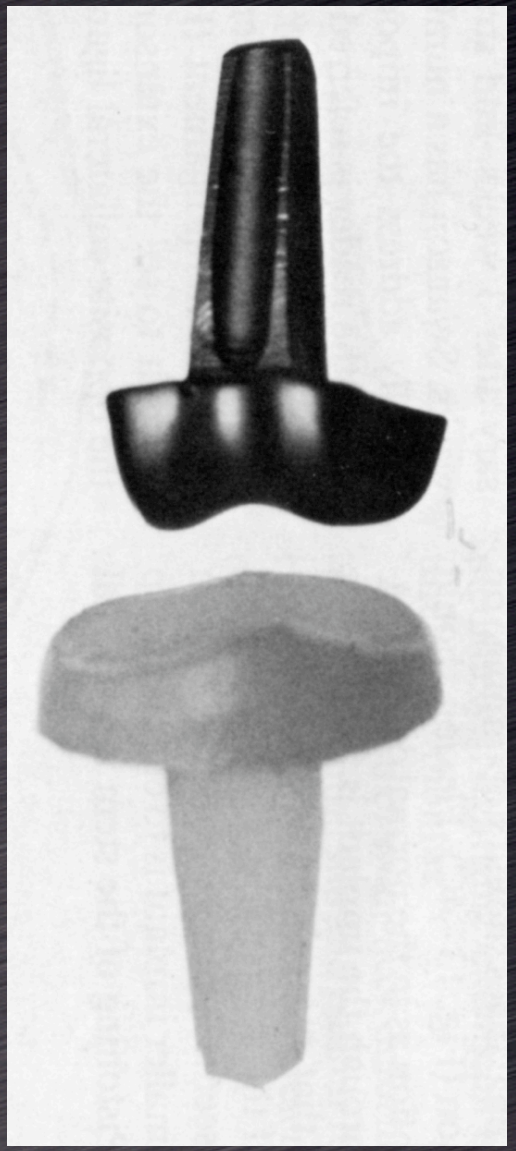
Titanium stems

- Moller reported the same experience at the PIP level



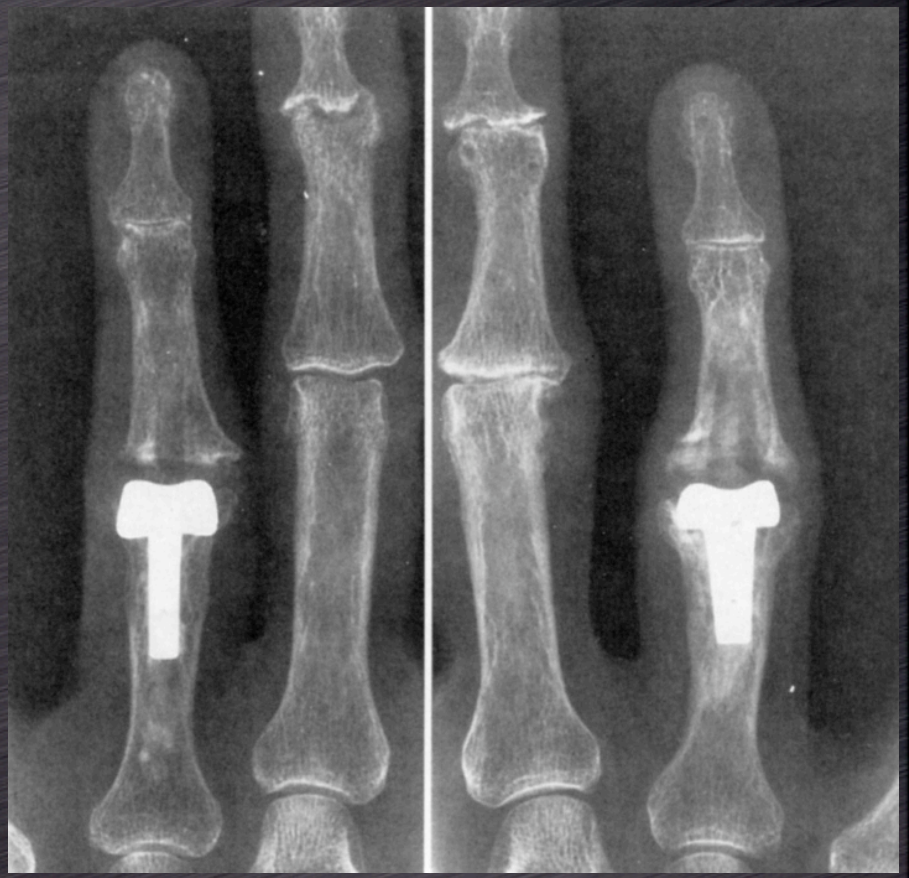
Resurfacing prosthesis

- 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

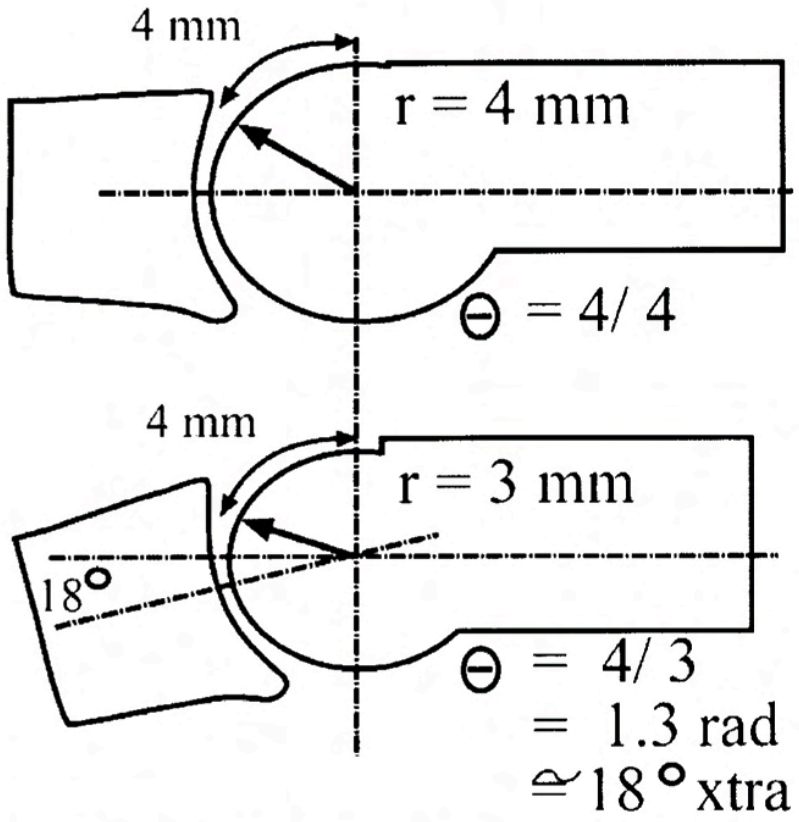


Figure 5. A change in the radius of curvature of the joint can alter the effective length of the tendons. In a semicircular joint configuration, the tendon will displace the length of the radius of curvature in 1 radian of angular displacement (57°). If the radius of curvature is decreased, the tendon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

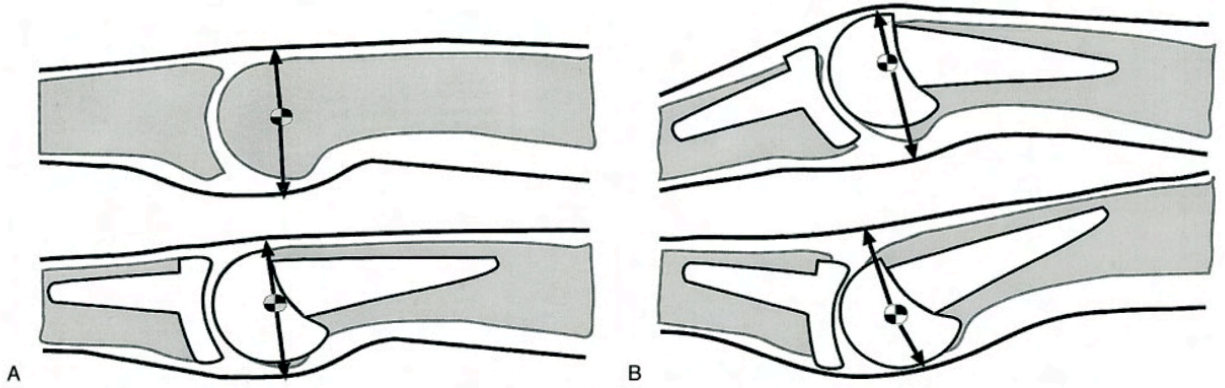


Figure 6. Sagittal moment arms. (A) Normal, correct placement prosthesis. (B) Dorsal displacement results in flexion stance; palmar displacement results in extension stance.

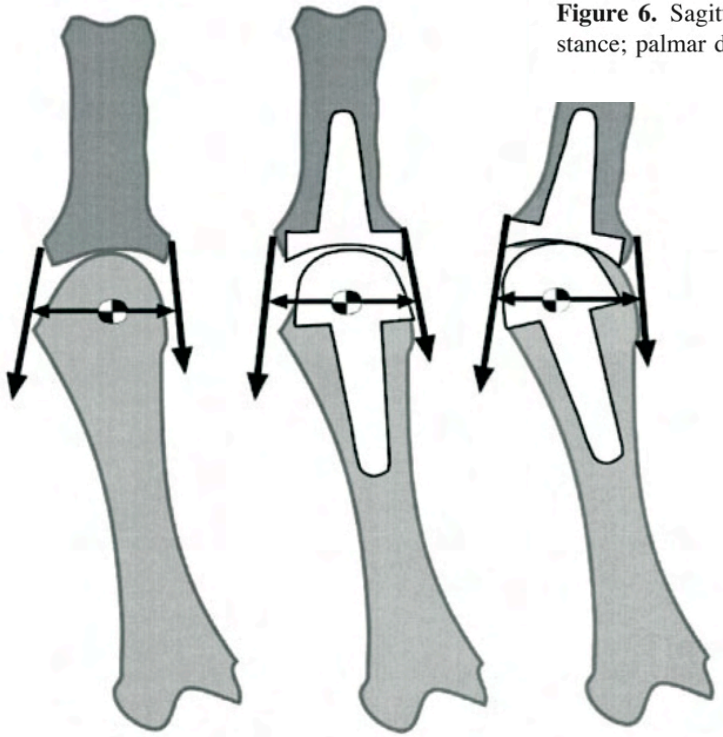


Figure 7. Coronal moment arms. (Left) Normal. (Center) The position of the prosthesis maintains correct moment arms. (Right) Radial displacement of the prosthesis results in unbalanced moment arms and ulnar deviation.

This is particularly true at the MP level whose anatomy is very different from the PIP joint

Resurfacing prosthesis

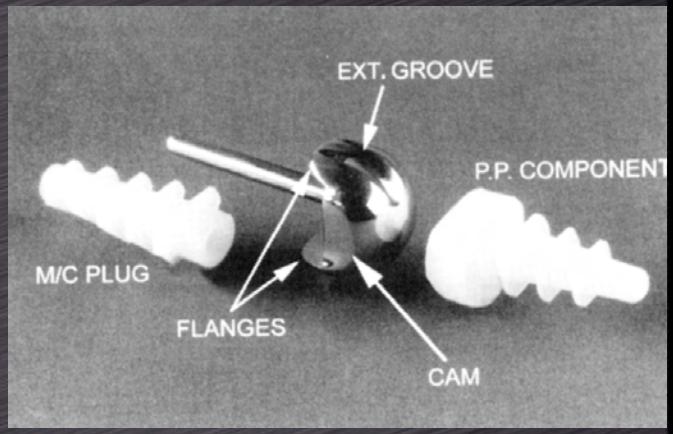
- Ascension (pyrocarbone)
- SBI (Avanta)
- Some warnings:
  - No bony fixation of the pyrocarbone implants
  - Huge constraints on the spongious bone
  - Squeaking of the prosthesis,..

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

	1	2	3	Total
MP	1777 Swanson	625 Avanta	219 Neuflex	2651
IPP	22 Swanson	10 Ascension	9 Avanta	57

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

Conclusion 3

- Swanson's design, which is very tolerant and easy to change is still the reference, even with its numerous complications
- New models have to proved their tolerance but also their ability to maintain or improved motion and their durability