

A 10-Year Follow-Up of Uncemented Constrained Metacarpophalangeal Joint Arthroplasties Using the RM Prosthesis in a Patient with Rheumatoid Arthritis.

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Abstract

A 72-year-old male with high-demand activities of daily living presented with rheumatoid arthritis mostly affected finger joints of his right hand. Radiographically, there was severe destruction with luxation of metacarpophalangeal joints (MCPJs) II-V. The constrained RM prostheses were inserted into the MCPJs II-V typically in the uncemented manner; and the course was primarily complicated due to periprosthetic fracture of the metacarpal IV intraoperatively, that was treated with immobilization in a plaster splint for 6 weeks. After that, the course was uncomplicated. Eight years after primary surgery, the patient reported increasing pain with loss of function isolated in his MCPJ IV since 6 months; all other finger joints did not reveal any clinically relevant symptoms. Radiographically, distinctive osteolyses with cortical thinning around all components of the 4 RM prostheses were seen, and the hinge joint of implant in MCPJ IV was broken. A total exchange arthroplasty of the MCPJ IV using the unconstrained MCPJ resurfacing SRTM MCP implant with cementation of both components was performed. At the 10-year follow-up, that includes a 2-year follow-up after MCPJ IV exchange arthroplasty, there was unchanged correct positioning of all MCPJ implants; and despite distinctive radiographic loosening and subsidence of the 3 other RM prostheses, the patient is able to perform his high-demand activities of daily living.

Key words: Rheumatoid arthritis; Metacarpophalangeal joint; Constrained arthroplasty; Resurfacing arthroplasty

Abbreviations

RA: rheumatoid arthritis

MCPJ(s): metacarpophalangeal joint(s)

PIPJ(s): proximal interphalangeal joint(s)

DIPJ(s): distal interphalangeal joint(s)

IPJ: interphalangeal joint

PEEK: polyetheretherketone

PE: polyethylene

UHMW: ultra-high molecular weight

CoCr: cobalt-chrome

ROM: range of motion

Introduction

The most frequent deformity of the hand occurring in patients with Rheumatoid Arthritis (RA) affects the metacarpophalangeal joints (MCPJs). The MCPJ is more intrinsically unstable than the other joints of the long fingers II-V and, therefore, more vulnerable to the deforming forces associated with RA [1]. The deformity is characterized by a palmar (sub) luxation of the proximal phalanges and ulnar drift of the fingers that is usually caused by the chronic synovitis which disrupts the ligamentous support of the joint. Consequently, the radial stress on the fingers with pinch drives the fingers in the ulnar direction. Patients presenting with this deformity often report inability to extend the fingers. Moreover, the deformity limits the ability to cut the fingers around larger objects, and fine pinch is obstructed because the index and middle fingers can no longer oppose the thumb in a tip-to-tip pinch [2].

A stable and functioning MCP joint is the key for satisfactory function of the overall finger in particular in RA patients with concomitant mutilating proximal interphalangeal joint (PIPJ) destruction Grade V according to the classification by Larsen et al. [3] when PIPJ and/or distal interphalangeal joint (DIPJ) fusions become necessary as the merely surgical treatment of choice (Figure 1A-B) [4]. The constrained MCPJ arthroplasty was designed to decrease the risk of recurrence of palmar (sub) luxation and ulnar deviation postoperatively due to the inherent lack of ligamentous support that was found in up to 31% of patients with RA who underwent a silicone rubber implant arthroplasty [5]. However, the rates of loosening and mechanical failure of almost all types of constrained prostheses are so high that their use cannot be recommended at present [6]; and the role of the piston effect, primarily known from the silicone rubber implant that increases the range of motion of the proximal phalanx, for breakage of prosthesis in cases of loosened non-silicone uncemented MCPJ implants such as in unconstrained resurfacing pyrocarbon arthroplasty [8, 9] or in constrained arthroplasty such as in our following case presentation, is not clearly understood currently. The second generation of the constrained and uncemented MCPJ RM prosthesis (Mathys, Bettlach, Switzerland) is one type that is in use [10].



Figure 1: (Introduction: Example for the necessity of a motion-preserving MCPJ procedure of a severely destructed right hand in a 74-year-old low-demand female with RA): (A) Mutilating destruction of PIPJs II-IV Grade V with ankylosis in ulnar direction (lines) that led to a malalignment of the silicone rubber implants (circles) in the MCPJs II/III of the same fingers in radial direction (lines), for those conditions motion-preserving arthroplasties in the PIPJs are not detected; **(B)** Same patient after surgical correction of the PIPJs II-IV in their anatomic axes (lines) with fusions, note there was a spontaneous realignment of the silicone rubber implants (circles) in the MCPJs II/III in their anatomic axes postoperatively (lines).

Case Presentation

A 72-year-old male with high-demand activities of daily living presented with RA mostly affected finger joints of his right hand. Radiographically, there was severe destruction with luxation of MCPJs II-V, and additionally, ankylosis with Z-deformity of the thumb (Figure 2A). First, thumb deformity was reconstructed with fusions of the MCPJ and interphalangeal joint (IPJ); and in a second procedure, the constrained RM prostheses were inserted into the MCPJs II-V typically in the uncemented manner. Note there was intraoperatively a periprosthetic fracture of the metacarpal IV at the tip of stem of implant that was seen on the radiograph 1 day postoperatively (Figure 2B). The fracture was treated conservatively with immobilization in a plaster splint for 6 weeks. The further course was uncomplicated.

Eight years postoperatively, the patient reported increasing pain with loss of function isolated in his MCPJ IV since 6 months; all other finger joints did not reveal any clinically relevant symptoms. Radiographically, distinctive osteolyses with cortical thinning around all components of the 4 RM prostheses accompanied with its subsidences were seen, and the hinge joint of implant in MCPJ IV was broken (Figure 2C). A total exchange arthroplasty of the MCPJ IV using the unconstrained MCP joint resurfacing SRTM MCP (formerly Avanta SR, Small Bone Innovations, Morrisville, PA, USA) implant with cementation of both components was performed, and intraoperatively, the breakage of the RM prosthesis was confirmed and both components were loosened (Figure 3A). The further course was uncomplicated again.

At the 10-year follow-up, that includes a 2-year follow-up after MCPJ IV exchange arthroplasty, there was unchanged correct positioning of all MCPJ implants (Figure 3B); and despite distinctive radiographic loosening and subsidence of the 3 other RM prostheses, the patient reported a good outcome regarding his finger functions and he is able to perform his high-demand activities of daily living again (Figure 4). Pain in visual analogue score (0 - 10 points) improved from 7 before MCPJ IV exchange arthroplasty to 2, and the patient reported that he would have the

same procedures again if it would be necessary.

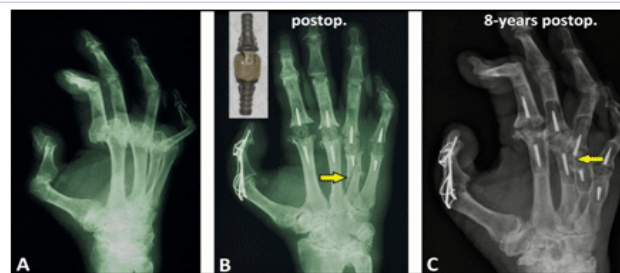


Figure 2: (Case Presentation): (A) Initial conditions with ankylosis/Z-deformity of the thumb and marked destructions with complete luxations in MCPJs II-V; **(B)** Surgical treatment with fusions of the thumb's MCPJ and IPJ, and MCPJ II - V arthroplasties using the RM prosthesis (with its design), note the periprosthetic fracture of the metacarpal IV (arrow) that was treated conservatively; **(C)** 8 years postoperatively there was a marked bone resorption with cortical thinning around all prostheses, and the MCPJ IV prosthesis was broken (arrow).

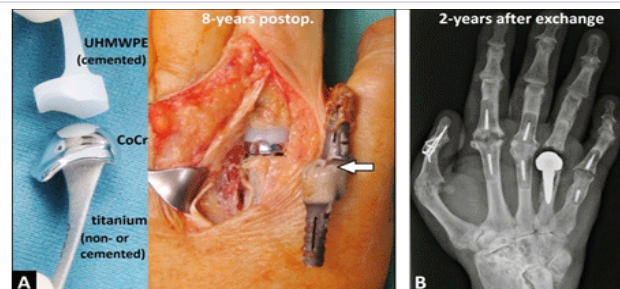


Figure 3 (Case Presentation): (A) Design of the SRTM MCP resurfacing implant and exchange procedure MCPJ IV intraoperatively, note the breakage of RM prosthesis in its hinge joint (arrow); **(B)** 10 years after primary MCPJ II-V arthroplasties and 2 years after MCPJ IV exchange arthroplasty, all RM prostheses of the MCPJs II/III/V well functioning despite marked signs of radiographic loosening and subsidence, SRTM MCP resurfacing implant in the MCPJ IV without any signs of radiographic loosening, and the wires for fusion of the MCPJ of the thumb were removed.



Figure 4: (Case Presentation): Clinical photographs demonstrating stable and well functioning MCPJ II-V arthroplasties at the 10-year follow-up (including the 2-year follow-up of MCPJ IV exchange arthroplasty) with correct alignment of the long fingers II-V; and additionally, fusions of thumb's MCPJ and IPJ accompanied with correction of its Z-deformity provide circumduction with sufficient object grasp, key and tip-to-tip pinch to perform his high-demand activities of daily living.

Discussion

The preservation of motion in the MCPJs II–V has a top priority. A stable and functioning MCPJ is the key for satisfactory function of the overall finger. The stable active extrinsic motion-arc modulates synergistically the intrinsic function in the PIPJ for a powerful extension and fist conclusion. On the other hand, the actions of the intrinsic muscles are necessary for stabilizing the MCPJ in flexion posture during PIPJ motion. Functional flexion postures averaged about 60° at the MCPJ and PIPJ, and 40° at the DIPJ [11, 12]. A MCPJ fusion should be avoided as a primary surgical procedure, and it is only considered when other surgical procedures have been failed [2, 11–14]. Despite the well-known high complication rate (wear-related synovitis and osteolysis, implant loosening and/or breakage), the silicone rubber implants, introduced in 1968 by Swanson [15] and its recent further development NeuFlex, introduced in 1998, are recommended unchanged for low-demand patients with RA (Figure 1A–B) [4, 16, 17], and MCPJ resection-interposition arthroplasties with the use of autologous soft tissue structures can be another option for these patients [11, 18–20].

For high-demand patients with RA such as in our case, stable and functioning MCPJ II–V arthroplasties have been recommended, and various (semi) constrained prostheses were designed (started in 1953 with the Brannon and Klein type; followed by other types since 1961: Flatt, Griffith-Nicolle, Schetrumpf, Schultz, Steffe, George-Buchholtz, Minami, Strickland, Walker, Weightman, Link, Weko, Daphne) to increase the grip strength and to decrease the risk of recurrence of ulnar deviation with or without (sub)luxation postoperatively due to the inherent lack of ligamentous support which is usually observed after silicone rubber MCPJ arthroplasties. The first type of the constrained and uncemented Mathys prosthesis, introduced in the 70th, was an all-plastic implant that consisted of a polyacetal-resin and a polyester component, a metal core, and a screw. The two components are implanted separately and are fixed intramedullary by an expanding mechanism (rawl plug principle). A cone shaped metal piece is pressed into the stem by a screw to secure the stems into the medullary spaces. The two components are snapped together afterwards (hinge joint). The main problem was the migration of the prosthesis so, within a few months postoperatively, the Range Of Motion (ROM) was very poor [21–23], which led to its withdrawal from the marketplace. The second design of the constrained Mathys prosthesis (RM prosthesis) with its hinge joint which was used in our case consists of two polyetheretherketone (PEEK) components (Figure 2B). There is an internal titanium screw for initial fixation and the stems are coated with titanium for bone ingrowth [24]. PEEK has been proven to be a biocompatible biomaterial and with sufficient strength for a joint replacement [25]. One retrospective study that compared the outcome of 86 silicone implants versus 22 RM prostheses for the MCPJs and PIPJs in a short to medium follow-up has been demonstrated a significant higher functionality and stability of the RM prostheses versus the silicone implants [10]. However, long-term results with a larger number of patients could not be found in the literature.

Hence, further studies are needed to validate the RM prosthesis. Intraoperative periprosthetic fracture in MCPJ arthroplasty such as in our case is a concern, its occurrence is reported to be 3% associated with an increased risk with the use of pyrocarbon implants, cementless fixation of components such as in our case, and in the presence of diabetes mellitus [26]. Ceramic prostheses for replacement of the small joints in the hand are discussed in general in the literature critically [27–30].

The new generation of MCPJ arthroplasty is unconstrained surface replacement either with pyrocarbon prostheses [8, 31, 32] or prostheses with a metal-on-polyethylene (PE) articulation [33, 34]. The goal of these prostheses is that they are low profile, anatomically designed implants limit the amount of bone removed [35]. The unconstrained partial cemented MCPJ resurfacing SR™ MCP implant is one of the new generation types that are current in use [36]. It has a cobalt-chrome (CoCr) alloy metacarpal hemispherical head that articulates against an Ultra-High Molecular Weight (UHMW) PE phalangeal component (Figure 3A). The phalangeal component is to be inserted generally with cementation, whereas the metacarpal component with its titanium coated stem was primarily manufactured for uncemented insertion based on the osseointegration concept for endoprosthetic reconstruction of small joints in the hand [37, 38]. However, if the metacarpal intramedullary space is widened due to bone resorption with cortical thinning such as in our case, cementation of the titanium coated stems, that is useful in PIPJ arthroplasty as well [39], is inevitable. The MCPJ is a condylar ball-and-socket joint with a convex surface on the metacarpal head and an incongruent (larger radius of curvature) concave surface on the proximal phalanx. The major problem of unconstrained resurfacing MCPJ implants is dislocation tendency in the ulnopalmar direction if the palmar plate and/or the collateral ligaments are insufficient. The SR™ MCP implant was designed to decrease this risk by having a greater arc of curvature on the dorsal aspect of the metacarpal component. In a biomechanical study, a higher intrinsic stability of this implant compared to un-affected human cadaver joints could be evaluated [40]. One disadvantage of this implant is that cement removal is difficult in the necessity of revision and also there is a concern about the effect of heat polymerization [41]. Ibsen Sørensen [42] reported in a prospective study including 105 SR™ MCP joint arthroplasties (88 patients with RA, including severe conditions such as palmar (sub) luxation preoperatively) with a follow-up from 1 month to 5 years (74 patients with a minimum of 1 year), that clinical parameters (ROM, pain, pinch grip) had improved, there was only 1 loosening of a metacarpal component after 3 years (0,95%), and early implant dislocation due to collateral ligament insufficiency was observed in 8 cases (7,6%) postoperatively. All 8 dislocated prostheses have survived after surgical repair of collateral ligaments without any negative influence on clinical parameters. However, in comparison to the use of constrained MCPJ arthroplasty with the RM prosthesis, long-term results with the use of the SR™ MCPJ resurfacing arthroplasty could not be found in the literature as well. The long-term survival rate for resurfacing pyrocarbon MCPJ arthroplasty is reported to be 81,4% [8].

Conclusion

To our knowledge, this is the first case report in the literature that describes the MCPJ arthroplasty with the use of the uncemented constrained RM prosthesis at a 10-year follow-up. Despite distinctive radiographic loosening and subsidences, of all 4 implants, 3 implants are well functioning with a satisfactory outcome in a RA patient with high-demand activities of daily living. This feature (discrepancy between radiographic findings and good subjective results and without necessity of surgical revision in the absence of clinical symptoms) is known from the use of the silicone rubber and pyrocarbon implants [4, 6, 8, 16, 17, 31]. However, due to the absence of larger case series with long-term follow-up's in the literature, it cannot be concluded that the RM prosthesis is really a reliable option for treatment of RA affecting the MCPJs. Additionally, our case presentation demonstrates that the unconstrained distally partial cemented MCPJ resurfacing SR™ MCP arthroplasty can be a motion- and strength-preserving salvage procedure after a failed primary constrained MCPJ arthroplasty. The cementation of the metacarpal component of this implant such as in our case is necessary if the metacarpal intramedullary space is widened due to loosening with bone resorption and cortical thinning based on a failed primarily inserted other implant.

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None.

Declarations

The author declares that he has none conflict of interests concerning this article.

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