Primary MCP Arthroplasty

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Introduction

A pain-free, stable, and mobile metacarpophalangeal (MCP) joint is important for good hand function. The MCP joint is most commonly afflicted by inflammatory arthritis, but post-traumatic arthritis and osteoarthritis are also common and can lead to substantial pain and dysfunction. Conservative treatments include activity modification, splinting, topical and oral anti-inflammatory medications, and steroid injections. Surgery is considered for chronic pain, deformity, and loss of function in patients who fail conservative measures.

The most common surgical options for the arthritic MCP joint include arthroplasty and arthrodesis. While successful arthrodesis can be pain relieving and is the preferred surgical treatment for the thumb MCP joint arthritis, it is less desirable in the fingers. In addition to the loss of flexion and extension of the joint, the inability to abduct and adduct the digits can result in diminished hand function, especially when more than one digit is fused.

Silicone MCP arthroplasty, introduced by Swanson in 1962, has remained the gold standard in surgical management of MCP arthritis, especially in patients with rheumatoid arthritis [1]. However, over the last two to three decades, the introduction of surface gliding implants has become an alternative to the traditional silicone implants. The primary choices in the United States include pyrocarbon (Integra Life Sciences, Austin, TX) and the metal-plastic surface replacement arthroplasty (Stryker, New Jersey). These implants have favorable material properties compared to silicone. However, they are modular and non-constrained and require more competent soft tissues to maintain joint stability.

The aim of this chapter is to review the indications, technique, and outcomes of primary MCP arthroplasty in the surgical management of MCP joint arthritis.

Silastic MCP Arthroplasty

Design Characteristics

Silicone MCP arthroplasty has been utilized for nearly 60 years. Introduced initially by Swanson,

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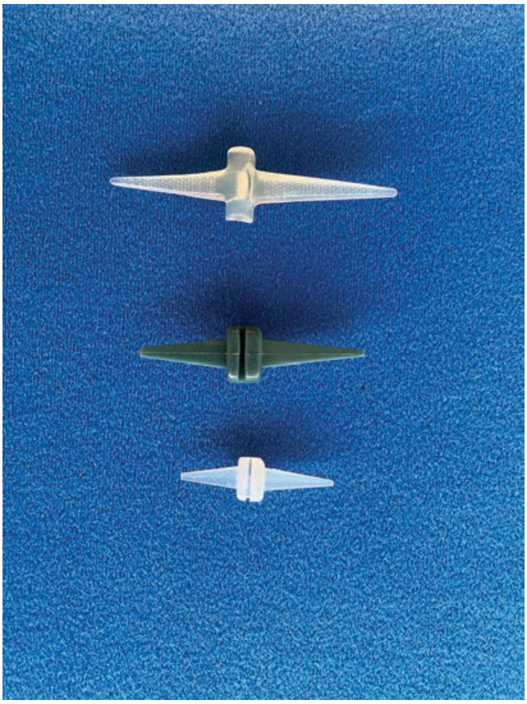

Fig. 17.1 The silicone MCP implants. The Swanson implant (top), the Stryker silastic implants (middle), and the Integra silastic implant (bottom)

they are one-piece intramedullary stemmed implants that provide some inherent stability and have a flexible hinge that allows for motion [1–3]. Numerous variations on the original design are available, but the general design features are similar (Fig. 17.1) [4–7].

Following implantation, a new joint capsule forms around the implant by means of encapsulation [8]. Excessive implant fixation or cementing has been shown to limit the longevity of this implant [3]. In fact, a small amount of pistoning and micromotion is advantageous, offloading the implant to ultimately improve survival. Like all implants, competent bone and soft-tissue joint stabilizers will share the load and improve stability and ultimately survival.

Short-term and some long-term subjective and objective results have been encouraging. Unfortunately, silastic implants have not been as durable long term, and component fracture and recurrent deformity have been observed. In addition, the debris associated with implant wear may create an inflammatory response, and even lymphadenopathy in some cases, resulting in silicone synovitis and further bone and joint destruction [9, 10].

Indications/Contraindications

Silicone arthroplasty is indicated for both inflammatory and noninflammatory arthritis of the MCP joint. While some of the newer modular implants are considered for noninflammatory arthritis, silicone remains the implant of choice in the management of inflammatory arthritis for most surgeons. Even with the success of disease-modifying antirheumatic drugs (DMARDs), many cases of MCP arthritis remain inflammatory in etiology. Thus, silastic implants continue to be a mainstay in the management of MCP arthritis.

Contraindications for silastic MCP arthroplasty include patients with incompetent musculature, insufficient bone stock, loss of neuromuscular function, and infection.

Technique (Fig. 17.2)

Silastic MCP arthroplasty is performed from a dorsal approach. In cases of multiple digits, a transverse skin incision over the MCP joints can be utilized. Alternatively a longitudinal skin incision(s) over the MCP joints may be performed. In nonrheumatoid patients, I prefer a tendon splitting approach to the joint, which is a similar technique to that described in the latter section focused on modular MCP implants.

In cases of inflammatory arthritis, we prefer an approach that splits the radial sagittal band. This allows for tightening of the sagittal band for extensor tendon centralization. The dorsal capsule is split longitudinally to reveal the joint. The bone cuts are then made, beginning first with the metacarpal head resection. These cuts are made perpendicular to the axis of the metacarpal or with a slight radial inclination in the coronal plane to counteract the tendency for recurrent ulnar drift. In the sagittal plane, the cuts are gen-

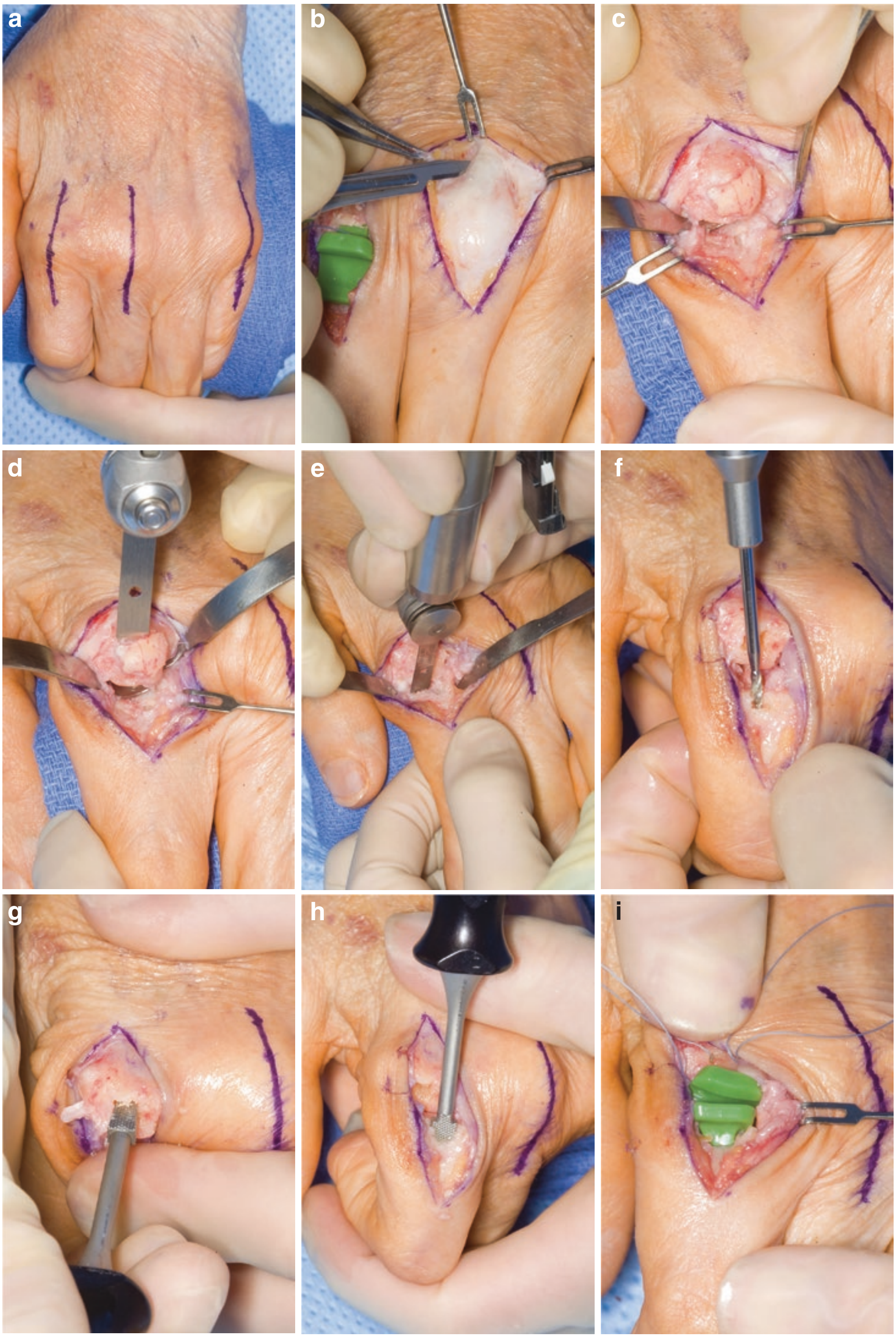

Fig. 17.2 Illustration of a case example silicone implants. (**a**) A longitudinal individual incisions or a single transverse incision (multiple digits) can be utilized. (**b**) The joint is exposed by dividing the radial sagittal band (seen on middle finger in this figure), and (**c**) the joint is exposed via a longitudinal incision of the capsule. The volar soft tissues are released. (**d**) The metacarpal cut is made with a transverse cut perpendicular to the axis of the shaft. (**e**) The proximal phalanx is also cut perpendicular to its axis, typically resecting a minimum amount to allow for access to the canal and correct erosive deformities. (**f**) A side-cutting burr can be utilized to help enlarge the canal, especially in patients with sclerotic bone. (**g, h**) Broaching up to the largest size and best fit is performed. (**i**) Trialing is completed and stability confirmed through the arc of motion. (**j**) The final implants are inserted, and (**k**) soft-tissue balancing can be then performed with collateral ligament suturing, followed by extensor tendon centralization

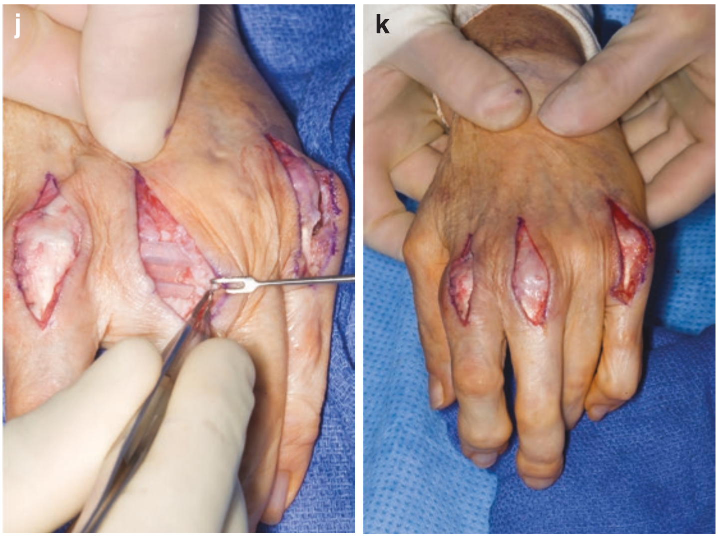

Fig. 17.2 (continued)

erally perpendicular, or slightly volarly angled, to the metacarpal axis. The proximal phalangeal cut is then made with care taken to simply remove 2–3 mm of the bone, again with the cut perpendicular to the axis of the phalanx on both coronal and sagittal planes. Broaching is then performed up to the largest size possible. Trialing is performed to assess for stability as well as motion. A good fit is such that there is a small amount of pistoning of implant with enough separation with the implant to avoid any type of impingement of the boney surfaces. The final component is then inserted.

This procedure in patients with inflammatory arthritis is often as much soft tissue as it is bony in nature. In patients with volar subluxation of the carpus, a volar plate and soft-tissue release can be helpful in maintaining the alignment of the arthroplasty and resisting recurrent joint subluxation. Coronal plane deformity can be corrected by plication of the radial collateral ligament and release of the ulnar collateral ligament when indicated. Both flexion and ulnar drift can be improved with an ulnar intrinsic release and even cross intrinsic transfers. Extensor tendon centralization can be achieved with tightening of the radial sagittal band and (when indicated) release of the ulnar sagittal band.

Postoperatively, the MCP joint is immobilized for 4 weeks in neutral alignment and extension allowing for IP motion. Alternatively, for patients with severe ulnar drift, an extension outrigger splint can be employed which allows passive extension and permits active flexion. At 4 weeks postoperatively, the patient can then graduate to a removable splint, and therapy working on motion and progression toward activities for daily living is initiated. Strengthening is initiated at 3 months postoperatively. Figure 17.3 and Video 17.1 highlights a case example of a patient who underwent successful silastic MCP arthroplasty for osteoarthritis.

Modular Surface Replacement Implants (Pyrocarbon and Metal-Plastic)

Pyrocarbon Implants (Integra Life Sciences, Inc., Austin, TX, USA)

Pyrocarbon is a unique material that makes us a two- to three-dimensional carbon matrix. It was initially introduced and has been utilized in replacement of heart valves for many years [11]. It is formed via pyrolysis of hydrocarbon gas,

Fig. 17.3 A 68-year-old female with pain and (**a, b**) advanced arthritis of the index and long finger MCP joints. (**c, d**) PA and lateral radiographs at 4 years postsurgery demonstrate some subsidence, but overall stable joints

whereby graphite is heated to 1300 degrees Celsius. The process results in a material with mechanical properties that fall between graphite and diamond.

With an elastic modulus very similar to the cortical bone, it serves as an excellent load-sharing device, minimizing stress-shielding. Pyrocarbon implants also exhibit exceptional

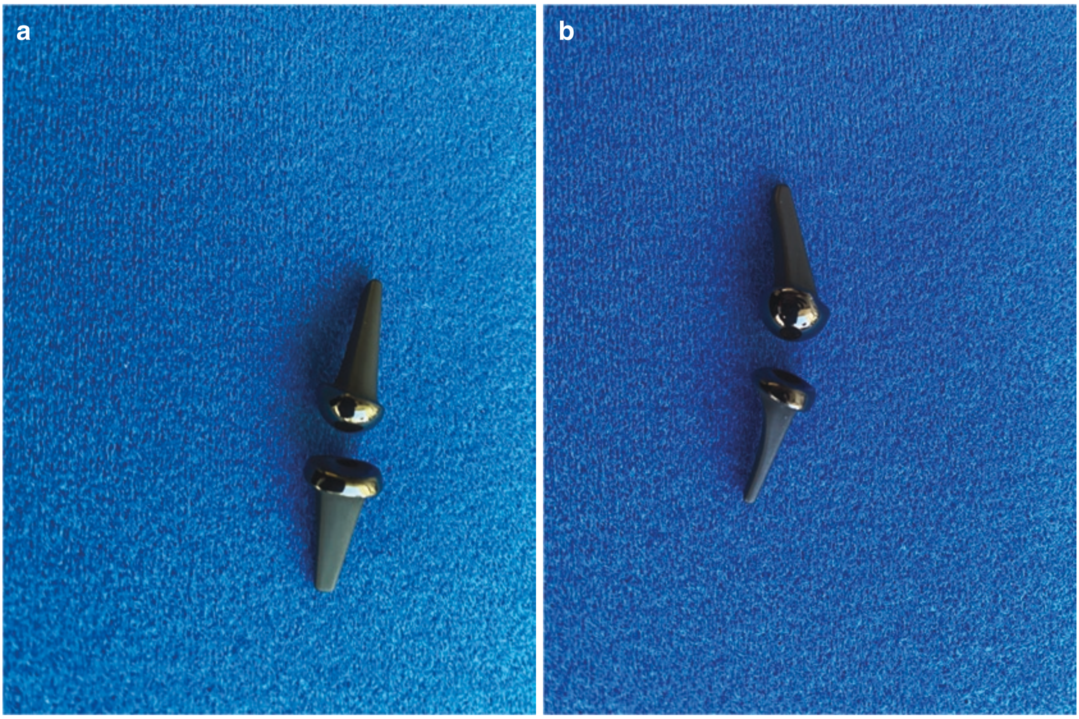

Fig. 17.4 The pyrocarbon implant. (**a**) View from the side and (**b**) view from above

wear characteristics, with minimal particular debris on repetitive cyclic loading. In addition, as it is biologically inert, the little particulate debris that these implants create is less likely to generate the immune-mediated responses that can be seen with silicone and polyethylene particles. Unfortunately, the stems of these implants have little/no osseous ingrowth and depend primarily on appositional growth of the bone around the implant to help provide stability. Animal studies have also demonstrated that, when compared to cobalt chrome, pyrocarbon can be a favorable "cartilage-friendly" articular surface [12]. In a hip hemiarthroplasty canine model, pyrocarbon yielded no inflammatory response and generated less surface cracks and promoted more fibrocartilage regeneration against its exposed articulation than cobalt chrome, suggesting that there is a role for it as a hemiarthroplasty.

Pyrocarbon was initially studied for application in small joint replacement in 1979 [13]. The original design has been modified from its inception. The current design is a polished pyrocarbon ball and socket joint anatomically and kinematically simulating the native MCP, maintaining its center of rotation and arc of curvature. The intramedullary stems are smooth, tungsten-coated pyrocarbon intramedullary stems (Fig. 17.4).

Metal-Plastic (SRA) Implants (Stryker Inc., Kalamazoo, MI, USA)

The SRA implant design is a cobalt-chrome-polyethylene implant with porous coated, titanium metacarpal component and all-polyethylene phalangeal component. (Fig. 17.5) Originally designed by Dr. Ronald Linscheid, it predates the pyrocarbon implant. Like the pyrocarbon implant, it is a ball-socket design better mimicking the anatomy and kinematics of the native MCP joint than silastic implants. The metacarpal head design is such that it has an offset, and narrows from dorsal to palmar, that helps provide stability with MCP flexion and laxity with extension. In addition, differentiating it from pyrocarbon, there

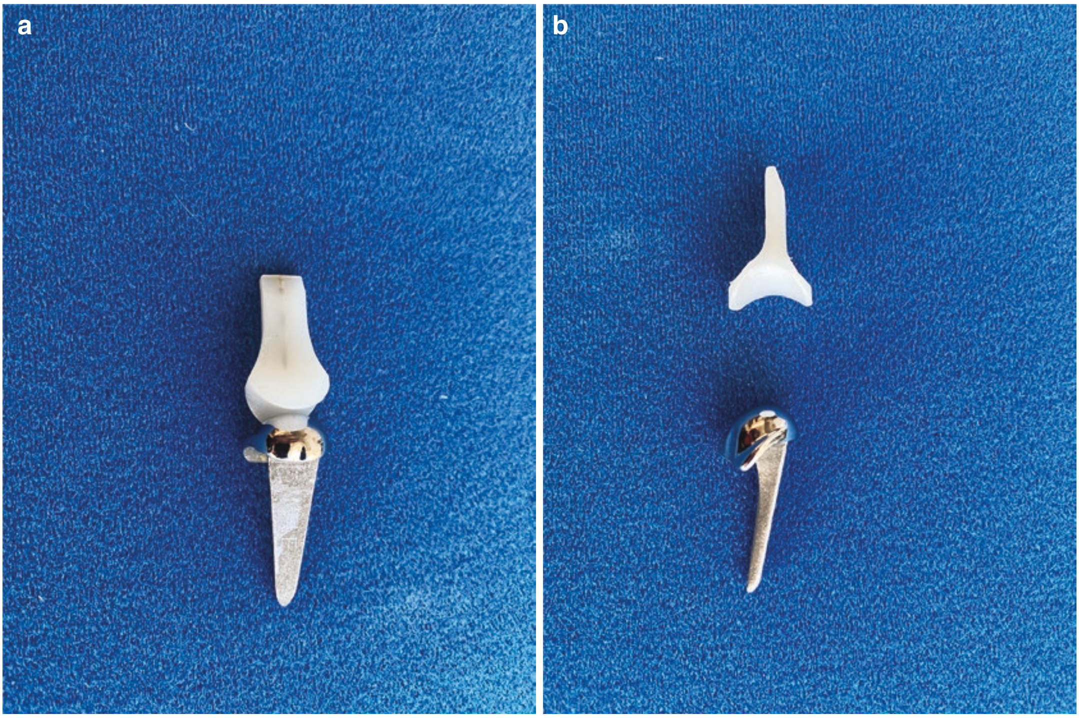

Fig. 17.5 The SRA implant. (**a**) View from the above and (**b**) view from the side

are radial-ulnar flares aimed at providing coronal plane stability, resisting the tendency for radial and ulnar drift of the digits. The proximal component titanium stem has flares that resist rotation and allow for ease of insertion. The distal component is all-polyethylene and requires cementing for fixation. The proximal component can be press fit or cemented. As a result, medullary canal bone-implant fixation is far superior with the SRA implant when compared to pyrocarbon implants.

Though it lacks the favorable material properties and wear characteristics of pyrocarbon, the polyethylene-metal articulation is reliable and has stood the test of time in joint arthroplasty. Advances in cross-linking of polyethylene have minimized the wear debris. While titanium's elastic modulus is further from that of cortical bone than pyrocarbon, it is a reliable load-sharing material and good at minimizing stress-shielding.

The use or need for cementing can be helpful for fixation to the bone but poses challenges in removing these implants. Resection of cemented components invites bone loss during removal.

Indications/Contraindications

The indications for surface gliding implants like pyrocarbon and SRA arthroplasty are similar to silicone and include osteoarthritis and post-traumatic and inflammatory arthritis. Given the less constrained design, it demands more soft-tissue competence for stability. As many patients with osteoarthritis have better soft-tissue stabilizers, the surface gliding implants are an excellent option for managing arthritis in this patient population. Figure 17.6 illustrates a case example of patient with osteoarthritis who underwent pyrocarbon MCP arthroplasty for middle finger MCP arthritis. Figure 17.7 illustrates a case example of a patient who underwent SRA arthroplasty.

However, most patients who present with MCP arthritis have inflammatory arthritis. These patients tend to have poorer soft-tissue compe-

Fig. 17.6 A 73-year-old female with significant (**a**, **b**) arthritis of her long MCP joint. She underwent (**c, d**) pyrocarbon MCP arthroplasty. Intraoperatively, she was lax at the radial collateral ligament

Fig. 17.7 (**a, b**) A 70-year-old male with advanced arthritis of the index and long finger MCP joints. He underwent SRA MCP arthroplasty. (**c, d**) Radiographs at 6 months postoperative demonstrated stable implants

tence and are vulnerable to recurrent deformity, dislocation, and instability. In these patients, the role of unconstrained surface gliding MCP implants is less clear. Patients with mild and/or well-controlled inflammatory arthritis are likely to be better candidates.

Contraindications to pyrocarbon and SRA implants include patients with poorly controlled inflammatory arthritis, significant deformities, ongoing or history of infection (relative), muscle incompetence, neurologic compromise, poor bone stock/quality, incompetent soft tissues, and unrealistic expectations.

Preoperative radiographs are critical in helping determine the feasibility of surface gliding implants. Patients with subluxation and frank dislocation of the MCP joints, as seen in cases of severe inflammatory arthropathy, are less likely candidates for the pyrocarbon or SRA joints. Further, chronic instability invites bone loss over the dorsal proximal phalanx, and the significant bone loss makes any implant arthroplasty a challenge, let alone less constrained prostheses. Also, significant ulnar drift of the MCP joints is linked to radial collateral ligament and sagittal band insufficiency which can undermine the success of gliding implants. Less severe or more subtle bone loss and ligament/soft-tissue laxity allows for a greater feasibility of surface gliding implants.

Due to its attractive biologic properties and its favorable wear characteristics, a novel indication for the use of pyrocarbon MCP arthroplasty lies in the setting of acute/subacute trauma. In these cases, it can serve as both a total joint replacement and a hemiarthroplasty. In fact, even in the setting of arthrosis, pyrocarbon hemiarthroplasty has been shown to be an effective option at a variety of joints including the wrist, shoulder, and thumb base as well as the finger [14–20].

Technique

The surgical approaches for insertion are similar to silicone implants, and a dorsal (for single and multiple digits) or transverse (for multiple digits) incision can be utilized. In patients with inflammatory arthritis, the radial sagittal band is released to expose the joint capsule which is then split longitudinally to reveal the joint. This allows for plication and centralization of the extensor tendons at closure. For osteoarthritic patients, a tendon splitting approach is appropriate, which can simply be re-approximated/repaired following implant placement. The MCP joint is then flexed and the metacarpal head exposed. At the dorsal one-third point of the metacarpal head, a k-wire can be used to confirm the start point for broaching. It is inserted longitudinally down the canal of the metacarpal and confirmed to be appropriately positioned with fluoroscopy. This also helps identify the start point for the alignment and cutting guide of the metacarpal.

With the pyrocarbon system, a cutting guide is placed and the distal metacarpal cut is made. The guide is then removed and the rest of the cut is made freehand. Clinically, this is an oblique cut that removes the entire metacarpal head while preserving the collateral ligaments. For the SRA implant, the metacarpal cut is made in a similar manner as that for silicone – simply perpendicular, or slightly radially inclined, to the coronal plane axis of the metacarpal at the bone-cartilage interface. Care should be made to protect the collateral ligament origin with the metacarpal head resection.

Resection of the metacarpal head allows for exposure of the proximal phalanx articular surface and the volar plate. A volar plate contracture release can then be performed, if indicated. For both the metal-plastic and pyrocarbon implant systems, the proximal phalangeal cut is perpendicular to the axis of the phalanx. This can be done freehand with the SRA technique. For the pyrocarbon system, an alignment/cutting guide is inserted in the canal at the dorsal third junction. A k-wire, followed by fluoroscopic evaluation, helps confirm the appropriate placement of the alignment guide. The cut at the proximal phalanx begins with the guide in place and is completed freehand after removal of the intramedullary guide.

After making the bone cuts, broaching is performed up to the largest size that fits the canals. The use of side-cutting burrs can be helpful in preparing the canals to maximize fit, especially in patients with thick cortices or healthier bone. The implant can then be trialed and the range of motion of the joint assessed. Stability can also be assessed in both coronal and sagittal planes. When indicated, adjustments to the soft tissues, such as tightening of collateral ligaments

(Fig. 17.6 and Videos 17.2 and 17.3) and further volar release, can then be performed, and the joint can be re-trialed in preparation for the permanent insertion.

If the joint is not stable enough following trialing with the surface gliding trials, the pyrocarbon system has silicone trials that match the bony cuts as a fallback option. The SRA implant manufacturer also has silicone implants that could be used if the surface gliding implants are no longer feasible. Following placement of the final components, the motion and stability are reassessed. Soft-tissue balancing is then completed and the extensor tendon repaired or centralized.

Rehabilitation protocols vary based on the diagnosis and severity of deformity and disease. In patients with rheumatoid arthritis, the first 3–4 weeks following surgery, a forearm-based splint immobilizing the MCP joints in extension, while allowing IP motion, is utilized. Thereafter, a low profile static splint is made for the patient, and a short-arc MCP motion protocol is initiated that increases the motion weekly or biweekly over the subsequent 4–6 weeks. At approximately 2–3 months post-surgery, the patient may begin strengthening.

Patients with osteoarthritis and those with more reliable soft-tissue stabilizers are able to progress with therapy sooner. Depending on joint stability and the status of the collateral ligaments, protected early motion can begin within 2 weeks. If collateral ligament tightening or soft-tissue balancing was necessary, then a longer period of immobilization (closer to that of patients with inflammatory arthritis) should be utilized.

Results in the Literature

Silicone

As it has been utilized the most between implant choices over the last 60 years, there is a broad experience with silastic implants for MCP joint reconstruction. Chung et al. examined the role of surgical intervention (n = 70 patients) when prospectively compared to medical management (n = 93 patients) for the treatment of rheumatoid arthritis with severe ulnar drift with and without extensor lag [21]. The groups matched nicely with respect to age, gender, race, education, and deformity. At 1-year follow-up, subjective and objective outcomes were improved in the surgically treated cohort. They concluded that while nonoperative treatment did not deteriorate over the 1-year follow-up period, surgery afforded deformity correction and improved function.

The silicone implant is very successful at early and intermediate follow-up with regard to pain, improvement in motion, and correction of extensor lag and coronal malalignment [4, 22–29]. Unfortunately, long-term outcomes show disappointingly high rate of implant fracture and recurrence of deformity [13–15]. Despite these complications, the rate of revision is surprisingly low for these implants, suggesting that implant failure does not equate to a universally poor outcome [3, 10, 13, 15, 16].

In the setting of rheumatoid and inflammatory arthritis, several large series have been reported with sizeable numbers and relatively longer-term follow-up. Goldfarb and Stern published their experience with 208 joints treated with silastic MCP implants with a 14-year average follow-up period [30]. Their findings demonstrated short-term improvements in alignment and MCP motion, with the mean arc of motion improving from 30 degrees (preoperatively) to 46 degrees postoperatively. However, over time the motion improvements decreased back down to 36 degrees at final follow-up. In a similar manner, the extension deficit improved significantly early postoperatively – from 57 degrees preoperatively to 11 degrees immediately postoperatively – and worsened slightly over time to 23 degrees at final follow-up. Ulnar drift similarly worsened over time from a near-neutral alignment to an average of 16 degrees. Implant fractures were also common, with 63% of implants broken, and implant fracture was associated with increased ulnar drift ($p < 0.001$). Subjectively, at final follow-up, only 38% of the hands were satisfied with their function and only 27% of the hands were pain-free. The authors concluded that long-term outcomes of silicone MCP arthroplasty for rheumatoid arthritis are associated with early good results that worsen over time. Trail et al. reviewed the outcomes of 1336 implants in 381 patients treated with silastic MCP arthroplasty over a 17-year period [31]. Their implant fracture's rate of 67% at final follow-up was similar to that of Goldfarb and Stern. However, the overall revision surgery rate was less than 6%. Adjunct procedures that improved survival included soft-tissue balancing, crossed intrinsic transfer, and realignment of the wrist. The use of grommets did not protect implants from fracture.

We examined our experience of 325 joints over a 14-year period with an average 7-year follow-up period [32]. The 5-, 10-, and 15-year survival-free from revision rates were 98%, 95%, and 95%, respectively. Radiographically, the outcomes were not as favorable, and the 5-, 10-, and 15-year survival rates free from radiographic implant fracture were 93%, 58%, and 35%, respectively. This appears to correlate with recurrent ulnar drift as the 5-, 10-, and 15-year survival rates free from coronal plane deformity of greater than 10 degrees were 81%, 37%, and 17%, respectively. Clinically, significant improvements in their postoperative pain levels and MCP arc of motion were experienced. We concluded that pain relief and functional improvement are reliable, but silicone MCP arthroplasty carries a high fracture rate over time, which correlates with recurrent ulnar drift.

Surface Replacement Arthroplasty (SRA)

The metal-plastic SRA is an established alternative to silicone for MCP reconstruction. Unfortunately, little has been published with respect to its use. As it was designed by Dr. Linscheid, we have had considerable experience with this implant at our institution, more for inflammatory than noninflammatory arthritis.

Claxton et al. reviewed the Mayo Clinic experience with the use of SRA implants for rheumatoid arthritis [33]. Eighty fingers in 27 patients underwent treatment with the SRA implant with a 9.5-year average follow-up period (minimum of 2 years). Pain relief, grip strength, and arc of motion were significantly improved. Thirteen fingers (16%) underwent revision and 29 (36%) needed reoperation. Kaplan-Meier analysis for survivorship at 1 , 5 , 10 , and 20 years was 100%, 95%, 85%, and 69%, respectively. Analysis for reoperations demonstrated 1-, 5-, 10-, and 20-year survival free from reoperation to be 89%, 80%, 65%, and 46%, respectively. Complications were not uncommon and included functional instability with and without joint subluxation occurring in 31% of digits. Less common complications included delayed wound healing, tendon or ligament rupture, ligament laxity, heterotopic bone, and synovitis. While the outcomes are worrisome to some degree, it may be more related to the diagnosis than the implant. The use of non-constrained implants in the setting of inflammatory arthritis carries greater risk of failures due to the poorer soft-tissue constraints in these patients.

With respect to the use of SRA in noninflammatory arthritis, there are no published reports to date. Our experience has been submitted and is awaiting review. It consists of 18 digits in 15 patients with an average 6.9-year follow-up period. Pain relief and functional improvement have been predictable, but the overall patient satisfaction rate is 72%. Unfortunately, three digits have necessitated revision surgery, and the Kaplan-Meier analysis for 2-, 5-, 10-, and 15-year survivorship was 89%, 89%, 76%, and 76% respectively. Five joints have required reoperation, and the most common indication for reoperation was stiffness. The KM analysis for reoperations at 2, 5, 10, and 15 years was 72%, 72%, 62%, and 62%, respectively.

Pyrocarbon

There have been numerous publications examining outcomes of pyrocarbon MCP arthroplasty [34–40]. Cook et al. were the first to publish their results and examined 71 MCP pyrocarbon arthroplasties in 26 patients at an average 12-year follow-up period [41]. Inflammatory arthritis was the most common diagnosis treated in the authors' experience. Kaplan-Meier analysis demonstrated an 82% 5-year and 81% 10-year survivorship, with a predicted 2% annual failure rate. Clinically, pain relief was generally excellent and MCP joint arc of motion improved 16 degrees. The patients achieved a more extended posture with an overall improved hand function. Radiographic outcomes (in 53 of 71 fingers) noted that 94% maintained MCP joint reduction. While there was a trend toward recurrent ulnar drift over time, at the most recent follow-up, the recurrent ulnar drift was not worse than preoperative measurements. The authors concluded that pyrocarbon arthroplasty was a viable option in the management of MCP joint arthritis.

Subsequent series have also reported encouraging outcomes, especially in treating patients with osteoarthritis. Parker et al. also examined a large series of 130 MCP primary pyrocarbon arthroplasties, of which 116 were available for radiographic analysis, with an average 17-month follow-up period [35]. Most of the patients had rheumatoid arthritis (96 joints) versus 20 joints with osteoarthritis. At this early follow-up, the authors noted a 99% survivorship and generally excellent clinical results and pain relief. Patient satisfaction was also greater than 90%. The overall complication rates were 6% minor and 9% major among the cohorts, with more in the RA group that included two cases of hand dysfunction and recurrent ulnar drift requiring repeat soft-tissue balancing, one patient with dislocation, and one case of stiffness that underwent manipulation under anesthesia. The OA group had two “major” complications: one extensor tendon disruption and another for persistent pain that required implant removal. Radiographically, the OA group had generally stable overall radiographic appearance. However, in inflammatory arthritis patients, the radiographic analysis was more worrisome. While most were not revised because the patient was asymptomatic, there was a 14% dislocation rate. In addition, nearly all (95%) had increased radiolucent seam, 55% had axial subsidence, and 45% were noted to have periprosthetic erosions.

Kopylov et al. reported their results with the use of pyrocarbon in patients with rheumatoid arthritis in 14 patients (40 fingers) [34]. The minimum follow-up period was 3 years. Clinically, all patients had pain relief and improved clinical outcomes and motion. Complications were noted in two joints: one patient was revised secondary to excessive loosening.

The results of pyrocarbon MCP arthroplasty have been promising for osteoarthritis. Wall and Stern examined 11 cases with a minimum 2-year follow-up (average 4 years) [38]. Range of motion was improved and pain relief was excellent, but grip strength did not improve. Patient outcome measures were generally excellent. All patients were able to return to their preoperative employment. Complications included one finger with extensor tendon subluxation, and another was revised to arthrodesis secondary to persistent pain. Radiographically, while there was an average 3 millimeter subsidence, no implant migration, fracture, or dislocation was experienced. They concluded that pyrocarbon MCP arthroplasty was a good surgical option for patients with osteoarthritis.

Nunez and Citron reported a short-term experience with the use of pyrocarbon MCP joints in patients with osteoarthritis [11]. In seven patients with ten MCP joints and an average follow-up of 2.2 years (range 1–4 years), they noted pain scores improved significantly. Radiographically, there was no evidence of implant failure or loosening. Overall, there were excellent patient satisfaction scores. The authors concluded that pyrocarbon MCP arthroplasty is a promising solution for osteoarthritis. In a larger series, Simpson-White and Chojnowski reviewed 18 fingers in 10 patients treated with pyrocarbon MCP arthroplasty for osteoarthritis, with an average follow-up period of approximately 5 years [38]. Pain scores and Quick DASH measures were all improved, with all but one patient being satisfied. Range of motion also improved. One case was revised to a silicone MCP implant due to negatively affected pinch. Radiographically, the authors also appreciated radiographic subsidence of the implants (and of some components up to 5 mm), but no dislocations or overt loosening. Similar to Walls and Stern, the authors concluded that pyrocarbon implants are a good option for the management of MCP joint OA.

In the largest published report to date, Dickson and colleagues examined outcomes of 51 fingers in 36 patients treated for osteoarthritis, with a minimum 5-year follow-up period (average 103 months) [37]. The authors noted that pain scores improved significantly postoperatively. The average VAS (1–10) final pain score was 0.9 (range 0–7). In addition, MCP range of motion averaged 54 degrees (range 20–80), and the final grip strength was 25 kg (range 11–45). The final Quick DASH and Patient Evaluation Measures (PEM) averaged 28.9 (range 0–56.8) and 26.5 (range 10–54), respectively. The overall implant survivorship was 88% at 10 years. The most common complication was dislocation, which occurred in three joints. They were treated as follows: one was stable following closed reduction, one was revised to silicone, and the third was "up-sized" to larger components. One patient had subluxation of the MCP joint, which was corrected with upsizing the implant. One case of CRPS was noted. There were two "late" complications of stiffness, which underwent manipulation and percutaneous soft-tissue release. One patient sustained a prosthetic stem fracture and another had aseptic loosening. Both of these cases were revised to silicone arthroplasty. Interestingly, all the implant revisions were performed within the first 18 months following surgery, and the authors attributed it to a learning curve and felt that this was a reflection more of "technical issues" rather than inherent problems with the implant. They concluded that, in nonrheumatoid patients, pyrocarbon MCP arthroplasty provides good pain relief, function, motion, and satisfaction.

Due to its material properties, durability, biomechanical characteristics, and features, pyrocarbon has been considered and utilized as a hemiarthroplasty. This has been described in the treatment of thumb CMC and finger proximal interphalangeal joint arthritis [17, 19, 42]. This has also been applied to the severely damaged MCP in the setting of trauma. Houdek et al. reviewed outcome of pyrocarbon MCP arthroplasty or hemiarthroplasty in the setting of trauma with a table saw and non-reconstructable cartilage loss, with a 4-year average follow-up interval [15]. Ten fingers in seven patients were treated that underwent MCP arthroplasty in the acute setting. Four patients were treated with a total MCP arthroplasty and six underwent hemiarthroplasty. At final follow-up, the mean MCP arc of motion was 56 degrees (range 30–70). Overall pain relief was excellent and there were no revision surgeries. No cases of infection occurred and the implants maintained stable position radiographically. There was a 50% reoperation rate for tenolysis, which is not that unexpected, given the fact that these patients had concomitant tendon injuries. The authors concluded that pyrocarbon can be viable option in the management of acute intra-articular trauma with resultant non-repairable cartilage injury.

Discussion

Patient selection is very important when deciding the optimal choice of implant. Most surgeons consider silicone to be the gold standard in the management of MCP arthritis, especially in cases of inflammatory arthritis. The lack of competent soft-tissue stabilizers invites recurrent deformity, subluxation, and instability. When considering surface gliding implants in the setting of inflammatory arthritis, these non-constrained implants should be reserved for patients with mild involvement and well-controlled disease. However, in the setting of osteoarthritis and stable post-traumatic arthritis, the surface gliding implants are an excellent alternative to silicone. When comparing the SRA and pyrocarbon, the literature reflects a larger experience with pyrocarbon. This may be due to the need for cementing with the SRA implant.

Good surgical technique is critical to help insure optimal outcomes with these implants. In the setting of inflammatory arthritis, it is very important to understand the "soft-tissue" balancing and stabilization are as (if not more) important than the bony procedure. This includes ligament balancing, volar capsule release, centralization of the extensor tendons, and (when indicated) intrinsic release/transfer.

With the surface replacement implants, protection of the collateral ligaments and preservation of bone stock are critical. Identification of the bone-cartilage interface along the dorsal distal metacarpal will serve as starting point for the bone cuts just distal to the collateral ligament origin. However, this may be altered by the arthritis, and care needs to be taken in removing the osteophytes prior to making this determination as it may result in excessive bone resection. Release of the volar plate and soft tissues may also be necessary when utilizing the surface replacement implants, especially if there is a component of preoperative subluxation. This maneuver helps ensure placement of the appropriate-sized implant and will help facilitate stability of the joint. Distally, only 2–3 millimeters of bone resection off the proximal phalanx is necessary. Removal of too much can negatively affect stability and compromise the collaterals, which insert on the volar aspect of the proximal phalanx. We encourage removal of all articular cartilage as this could result in recurrent episodes of inflammation. At the time of implant trialing, it is important to achieve some hyperextension (of approximately 10 degrees). If you have difficulty with extension, the patient is at risk of an extension lag, which we find is more frustrating to patients than limited flexion.

Volar osteophytes are not uncommon, especially in more severe arthritis, and these can limit flexion and/or result in deviation of the finger as it flexes. It is important to remove them and confirm, when trialing, that they are not impacting joint motion and gliding. A side-cutting burr can be very helpful in these cases as it helps prepare the canals for broaching, especially in patients with sclerotic or hard bone. When indicated, I prefer impaction bone grafting over cementing into the canals and using the bone from the resected metacarpal head. Impaction grafting can help improve fit and alignment of the components.

When considering the soft tissues, the ligaments can be reinforced, tightened, or repaired by placing holes drilled with a 0.045 k-wire or a 2 mm drill in the dorsal radial aspect of the distal metacarpal or through the footprint of the origin of the collateral ligament within the metacarpal head sulcus. This repair can be achieved with absorbable or nonabsorbable sutures including a 3–0 mersilene, 3–0 fiberwire, 2–0 ticron, or 3–0 vicryl, depending on the tissue quality, sizes, and degree of laxity. It is important to have the sutures in place before placement of the final components, and secure the sutures following placement of the implant. If the implant fit is poor at the time of trialing, either more bone resection or placement of larger implants may be needed. In addition, silicone implants can serve as a bailout if stability cannot be achieved with the modular joints.

Special consideration is necessary when treating the index finger. Due to the loads across its MCP joint due to lateral pinch, proper assessment before and after surgery is important at the index finger. Instability at this joint can be very challenging. Care should be taken in preoperative assessment of these digits and intraoperative stability following implant placement. Radial collateral ligament reinforcement is often utilized in my experience, and my threshold for immobilizing the MCP joint for longer periods of time and in slight radial deviation is lower.

Finally, and not least, appropriate hand therapy is essential for a good outcome. The postoperative regimen has evolved over the years and ultimately has been simplified at our institution. Depending on intraoperative stability, the hand is immobilized with the MCP in extension, allowing for IP motion. After 1–4 weeks, depending on the diagnosis and intraoperative findings, the patient graduates to a removable orthosis that also holds the MCP joint in extension and allows for IP motion. A short arc type of protocol is begun, which progressively increases active MCP motion 10–15 degrees weekly until 75–80 degrees is reached. Patients with inflammatory arthritis require a heightened awareness of coronal plane alignment. At 3 months postoperative, the patient may begin strengthening exercises.

Because of the functional limitations associated with arthrodesis, arthroplasty is an important treatment for MCP joint arthritis in patients with both inflammatory and noninflammatory arthritis. Silicone remains the gold standard and the primary treatment for patients with RA. Newer implants, including pyrocarbon and metal-on-plastic designs, with more favorable material properties, have the potential to become the preferred option for noninflammatory arthritis. In our practice, they have already become the first choice for patients with osteoarthritis. Future advances and study will further define the role of this surgery and best treatment options.

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