Implant Arthroplasty for Proximal Interphalangeal, Metacarpophalangeal, and Trapeziometacarpal Joint Degeneration

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Learning Objectives

Upon completion of this CME activity, the learner should achieve an understanding of:

- The role of silicone arthroplasty at the metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints
- The current status of metal-plastic surface replacement arthroplasty and pyrocarbon arthroplasty
- The objectives of trapeziometacarpal (TMC) implant arthroplasty to overcome some of the deficits still encountered with trapezial resection arthroplasty
- The current difficulties encountered with implant arthroplasty at all 3 of these joints

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Arthritis of the hand can result from inflammatory arthritis, osteoarthritis (OA), or be post-traumatic and can cause pain and debilitation. Arthroplasty serves as 1 surgical option in the surgical management of arthritis and aims to create a pain-free joint with preservation of motion. Although implant arthroplasty of the proximal interphalangeal (PIP), metacarpophalangeal (MCP), and trapeziometacarpal (TMC) joints predictably produce pain relief and high

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satisfaction, it has historically suffered from high rates of complications. The hinged silicone prosthesis was 1 of the early implants and, in many cases, remains the gold standard. However, problems with deformity correction, implant fracture, and synovitis remain. Implants made of alternative materials such as metal-plastic and pyrocarbon have evolved; however, survivorship and reoperation rates remain a concern. This review details the evolution and current options available for small joint implant arthroplasty involving the MCP, PIP, and TMC joints. *(J Hand Surg Am. 2017;42(10):817–825. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words PIP, MCP, small joint, implant arthroplasty.

Arthritis in the proximal interphalangeal (PIP), metacarpophalangeal (MCP), and trapeziometacarpal (TMC) joints is relatively common, leading to disability, pain, and disfigurement. When nonsurgical measures have been exhausted, several different surgical options exist to treat arthritis of the MCP, PIP, and TMC joints. In the MCP and PIP joints, the 2 primary options involve implant arthroplasty or arthrodesis. Although arthrodesis predictably produces a stable, pain-free joint, its limitations in motion and function are important considerations. There are many options to treat arthritis of the TMC joint, including trapezium resection alone, trapezium resection with soft tissue interposition alone or in combination with metacarpal stabilization, or TMC arthrodesis. In recent years, implant hemiarthroplasty has been described for the TMC and PIP joint arthritis.

PROXIMAL INTERPHALANGEAL JOINT ARTHROPLASTY

The PIP joint destruction is often from OA or posttraumatic degeneration, posing unique challenges given its multiple soft tissue components critical to joint motion and stability. The most common implants utilized include: silicone, pyrocarbon, or metal-plastic surface-replacement arthroplasty (SRA).

Silicone

The hinged silicone implant is effectively designed as a spacer, which allows some motion of the joint. The implant itself is not designed for bony ingrowth; instead it relies on the formation of a capsule around the prosthesis and proper tendon and ligament balance to maintain stability. Although silicone is generally well tolerated in the body, microscopic particulate debris may result in pain and destruction owing to a local inflammatory response.

Silicone implants generally provide good pain relief and patient satisfaction in patients with inflammatory arthritis, OA, and PTA. However, motion improvements are less predictable. In a clinical assessment by Takigawa et al,[1] 40 patients experienced either minimal (n = 34) or no (n = 6) improvements in their PIP motion, and 30 had a decrease in their total arc of motion. In addition, Bales et al[2] and Ashworth et al[3] both observed an insignificant decrease in their total arc of motion after surgery by 5° and 9°, respectively. However, patient satisfaction can be good. Bales et al[2] reported high satisfaction with the procedure and the overall outcomes, but were neutral when specifically asked about the finger appearance, range of motion (ROM), and function, which highlights 1 of the primary shortcomings of silicone: correcting coronal plane deformity.

Implant survivorship with silicone has been satisfactory. Swanson et al[4] demonstrated only a 10.9% overall revision rate in their analysis of 424 silicone PIP arthroplasties. Bales et al[2] examined 38 PIP joint arthroplasties, finding excellent pain relief, maintenance of PIP joint motion, and a 90% 10-year survival rate. Other studies have reported 5- to 10-year survival rates from 81% to 80%.[1–3]

Despite predictable pain relief, good patient satisfaction, and implant survivorship, silicone arthroplasty has been associated with various complications, including implant fracture (Fig. 1), synovitis, and instability.[2–4] Unfortunately, fracture can result in malalignment. However, because many of these patients are pain-free and maintain a satisfactory level of function, they do not require any additional procedures.[1,2] Silicone synovitis is another clinically concerning problem that may necessitate implant removal secondary to pain and bone loss, with reported rates from 0% to 24%.[1,3]

Metal-plastic SRA

A nonconstrained metal-plastic SRA design was created to be a more anatomical joint. It consists of a proximal cobalt chromium and distal metal-backed polyethylene-titanium distal component (Fig. 2).[5] Whereas the material properties of this implant allow for better coronal plane deformity correction, because it is

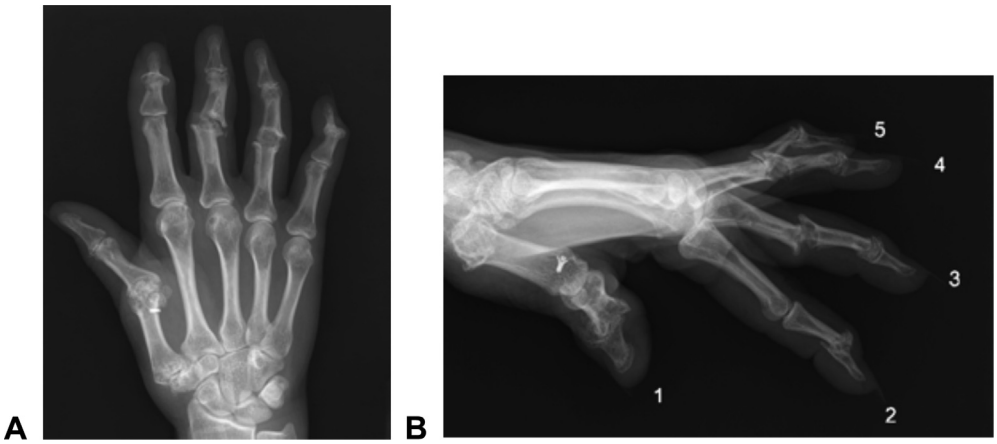

FIGURE 1: **A** Anteroposterior and **B** lateral x-rays of a patient who experienced silicone implant fracture approximately 3.5 years after insertion and subsequently developed dislocation of the middle finger PIP joint.

FIGURE 2: **A** Anteroposterior and **B** lateral x-rays of a patient with OA who underwent SRA implant for her ring finger.

modular, it lacks the inherent stability of the hinged silicone prosthesis that can be concerning in patients with poor soft tissue stabilizers.

Murray et al[6] examined medium- to long-term outcomes of 67 metal-plastic PIP arthroplasties, demonstrating an 89% 5-year survival and 84% 15-year survival, with a mean total PIP arc of motion of 40°. Unfortunately, other studies have been less encouraging. Luther et al[7] in a study of 24 SRAs performed in 9 OA and 15 PTA patients, observed a reoperation rate of 58% for complications including tendon adhesions (n = 9), swan neck deformity (n = 3), prosthesis loosening (n = 2), prosthesis migration (n = 1), and infection (n = 1). Because early designs of the SRA necessitated the use of cement, outcomes with and without its use have been examined. In a long-term retrospective study comparing cemented and noncemented SRAs by Johnstone et al,[5] there were no differences in pain scores or arc of motion, although the cemented implants had a higher revision rate (26% vs 8%), and the noncemented components had a higher rate of radiographic implant loosening. In contrast, the study by Murray et al[6] found no difference in clinical or radiographic outcomes when comparing cemented (72%) and noncemented (28%) implants.

Pyrocarbon

The nonconstrained pyrocarbon implant was also developed to provide patients with an alternative to

FIGURE 3: A Lateral and **B** anteroposterior x-rays demonstrate migration and loosening of the middle finger pyrocarbon proximal component in an OA patient.

silicone and SRA. Pyrocarbon is biologically inert, has favorable wear characteristics, and has elastic modulus similar to that of bone. The implant stems have no bony ingrowth.

Its use in PIP joint arthroplasty remains controversial. Some reports demonstrated reasonable implant survival and relatively low complications,[8,9] whereas others have demonstrated high rates of complications and revision surgery.[10] Most studies have reported predictable pain relief and maintenance of PIP motion.[8,9] However, Sweets and Stern[10] found a gradual decrease in motion over time.

Pyrocarbon implant survival has been more variable. Some results have been encouraging. Watts et al[9] review of 97 pyrocarbon implants demonstrated an 85% 5-year survival rate, and Tagil et al[8] found only 10 of 89 arthroplasties required secondary procedures over a 10-year experience.

Pyrocarbon is vulnerable to implant migration (Fig. 3), dislocation, contracture, and squeaking. Sweets and Stern[10] reviewed 31 arthroplasties and found poor joint motion coupled with a high rate of revision surgery (16%), dislocations (16%), and implant fracture (3%). Nunley et al[11] also found the results to be concerning in the setting of PTA, with only slight improvement in pain and a high complication rate with no improvement in PIP joint motion, and have since stopped using pyrocarbon implants. Furthermore, a meta-analysis of 718 arthroplasties found higher rates of complications associated with the use of pyrocarbon (30%) versus silicone implants (8%).[12]

Owing to lack of bony ingrowth, pyrocarbon rates of migration/loosening have been as high as 64%.[10,13] Herren et al[13] found a disturbingly high rate of implant migration in 17 pyrocarbon arthroplasties. Sweets and Stern[10] found a 48% rate of catastrophic migration. Although worrisome, loosening is not universally associated with worse clinical outcomes.[9]

Comparative studies

Daecke et al[14] performed a comparative study examining outcomes among different implants. Their prospective randomized multicenter study examined outcomes in patients treated with OA using silicone, SRA, and pyrocarbon implants. A total of 43 patients (62 joints) were treated at a nearly 3-year follow-up period. Eighteen Silastic implants, 26 metal-plastic, and 18 pyrocarbon joints were utilized. Outcomes demonstrated that the reoperation rates were notably higher in the modular (metal-plastic and pyrocarbon) groups. The explantation rates were 11% for Silastic, 27% for titanium, and 39% for pyrocarbon. Pain relief and pinch strength were improved with all 3 devices. Although there was no notable difference in ROM among groups, the SRA implant showed a tendency toward higher maximal ROM although not statistically significant. Disabilities of the Arm, Shoulder, and Hand scores were significantly improved in the pyrocarbon and silicone groups. The pyrocarbon implants demonstrated a 72% incidence of radiographic abnormal lucent lines, compared with 31% with the SRA implants. The authors concluded that despite a potentially better ROM with the SRA implants, no differences were found in subjective and objective clinical outcomes between groups. The pyrocarbon and metal-plastic joints had notably higher reoperation and explant rates.

METACARPOPHALANGEAL JOINT ARTHROPLASTY

Degeneration of the MCP joint is more often the result of rheumatoid arthritis (RA) than of OA. Given that MCP arthrodesis is poorly tolerated, implant arthroplasty remains the preferred surgical treatment for MCP joint arthritis. Currently, the 2 most common implant options for the MCP joint include the silicone and pyrocarbon implants, with the metal-plastic SRA a distant third.

FIGURE 4: Anteroposterior x-ray of a 63-year-old man who underwent pyrocarbon arthroplasty for OA of the index finger MCP joint.

Silicone

Like the PIP joint, the hinged MCP joint silicone implant is designed to maintain a joint space and alignment, while relying on the formation of a capsule around the arthroplasty and proper tendon and ligament balance to maintain stability. In a recent randomized controlled trial, silicone MCP joint arthroplasty has demonstrated excellent patient satisfaction and better outcomes than nonsurgical treatment in RA patients with severe hand deformities.[15]

Patients often experience pain relief, improved postoperative motion, improved ulnar deviation, and satisfaction with silicone.[16] However, Hansraj et al[17] observed a decrease in ROM after surgery, and Olsen et al[18] found variable pain relief and satisfaction. Patients suffering from noninflammatory arthritis also experience pain relief, increased ROM, and satisfaction with silicone arthroplasty.[19]

Longer-term results have been less satisfactory, often noting recurrence of deformity and decrease in ROM.[20] Historically, silicone MCP joint arthroplasty has also suffered from implant fracture with rates as high as 63%.[20,21] Fracture has been associated with recurrence of ulnar deviation and negatively affecting MCP motion.[20] Goldfarb and Stern[20] examined 208 MCP joint arthroplasties using the silicone implant in patients with RA. At 14 years after surgery, patients experienced limitation in MCP ROM (36°), recurrent ulnar drift (16°), and only 27% of hands remaining pain-free at last follow-up.[20] In a study of 1,336 arthroplasties, Trail et al[21] found 10- and 17-year survival rates of 83% and 63%. Furthermore, in those with radiographic evidence of implant fracture, 10- and 17-year survival rates dropped to 58% and 34%, respectively. Interestingly, previous thumb surgery and postoperative manipulation of fingers were associated with revision, whereas lower degree of MCP preoperative ulnar deviation and addition of a crossed intrinsic transfer were associated with a decreased revision rate. In contrast, in a study of 170 implants, Hansraj et al[17] observed 5- and 10-year survivorship of 94% and 90%, respectively. Implant fracture, in and of itself, is not necessarily associated with decreased patient satisfaction or the need for reoperation or revision.[21]

FIGURE 5: Anteroposterior x-ray of a 48-year-old right-handed woman 1 year following pyrocarbon TMC joint hemiarthroplasty.

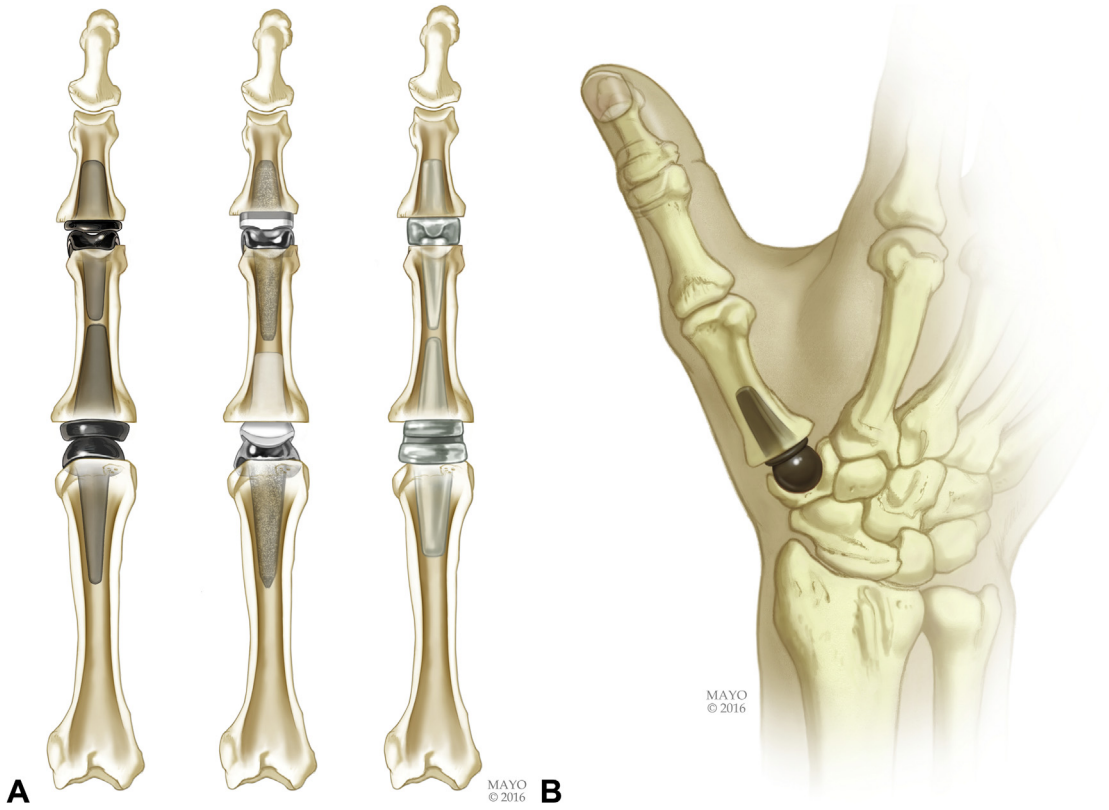

FIGURE 6: Small joint arthroplasties of MCP and PIP joints using **A** pyrocarbon (left), SRA (middle), and silicone (right); and **B** carpometacarpal joint with pyrocarbon hemiarthroplasty.

Pyrocarbon

Similar to silicone, the pyrocarbon implant (Fig. 4) has been associated with excellent pain relief, increased postoperative motion, improved hand appearance, and high patient satisfaction.[22,23] Because of its unconstrained design, its use in RA has been a concern. However, most investigators agree that it is a valid treatment for OA. Dickson et al[22] observed, in a study of 36 noninflammatory patients, a 10-year survivorship of 88%.

Overall, studies have demonstrated relatively low rates of complications with the MCP pyrocarbon implant.[22,23] Complications can include subsidence, dislocation, intraoperative fracture, asymptomatic squeaking, and loosening. Although not a complication, it should be noted that asymptomatic lucency around the implant was commonly found. Wall and Stern,[23] in a review of 11 implants with mean follow-up of 4 years, observed asymptomatic lucency and subsidence in all patients, along with the development of asymptomatic squeaking (n = 2), joint stiffness (n = 1), unexplained pain (n = 1), and extensor tendon subluxation (n = 1). In a long-term study (mean follow-up, 103 months) of 51 implants in 36 noninflammatory arthritis patients, Dickson et al[22] observed the development of 10 (20%) complications including intraoperative fracture of the proximal phalanx (n = 1), implant stem fracture (n = 1), complex regional pain syndrome (n = 1), dislocation (n = 3), subluxation (n = 1), stiff joints (n = 2), and aseptic loosening (n = 1). Of note, no correlation was found between degree of loosening or subsidence and outcome.[22]

TRAPEZIOMETACARPAL JOINT ARTHROPLASTY

Traditionally, nonbiological TMC joint arthroplasty has been reserved for Eaton stage II and stage III OA, with stage IV OA a contraindication. However, some studies have suggested late-stage arthritis not to be a contraindication to arthroplasty.[24,25] In contrast to the MCP and PIP joints, the challenges of nonbiological arthroplasty in the treatment of TMC joint arthritis lies in the reality that motion-preserving trapezial resection–based procedures exist and have an established track record of success.

Total joint arthroplasty

Total joint arthroplasty of the TMC joint uses a ball-and-socket prosthesis with cemented and cementless models available. Although different implants have been used in TMC total joint arthroplasty, there remain

a paucity of high-quality studies evaluating the efficacy of these prostheses.[26] Of the available implants, the de la Caffiniere prosthesis is considered to be the most commonly used with the most evidence available.

Results with the de la Caffiniere prosthesis have demonstrated good pain relief, with satisfactory mobility and strength.[24,25,27] A long-term study with an average of 19 years (range, 16–26 years) follow-up observed a reoperation-free survivorship of 74% and revision-free survivorship of 26% at 26 years, whereas 35% of implants had evidence of radiographic loosening. Likewise, van Cappelle et al[25] observed an implant survivorship rate of 72% at 16 years with failure of the arthroplasty as the end point.

One important complication of the de la Caffiniere prosthesis has been loosening of both components, particularly in men and in younger women.[25] Comparisons between cemented and noncemented prostheses of the TMC joint found that both suffered from loosening.[28] Given the high rates of loosening, the indications seem isolated to the elderly, and although still utilized in Europe, TMC total joint arthroplasty has largely fallen out of favor in the United States.

In contrast to the ball-and-socket designs, an SRA has been proposed and utilized.[29,30] Early clinical results of SRA have demonstrated the ability to provide pain relief, improve motion, increase strength, and result in reasonable patient satisfaction.[29,30] At an average of 33 months follow-up in a retrospective review of 20 arthroplasties, Perez-Ubeda et al[29] found a significant improvement in thumb abduction, Kapandji score, and lateral and tip pinch strength. Postoperative subjective functional evaluation found excellent or good results in 84.2% of patients; however, after 3 years, this decreased to only 42.1% of patients and sheds light on the need for more long-term studies.

Relatively high rates of complications are associated with the SRA implants, including loosening, dislocation, and nerve injury.[29–31] Although van Rijn et al[30] experienced no loosening in a study of 15 prostheses with an average follow-up of 36 months, loosening was the most common complication in the other short-term studies with rates of 55%[29] and 19%.[31] Pendse et al[31] found risk factors for loosening included younger patients, dominant hand, and a nonsignificant increase in those with bilateral SRA. Similarly, Perez-Ubeda et al[29] observed a nonsignificant increase in loosening with younger age, dominant hand, and in patients with MCP hyperextension before surgery. Moreover, loosening was found in 20% of implants at 1 year and increased to 55% at final follow-up (average, 33 months).[29] Survivorship analysis revealed a 91% survival rate at 3 years.[31]

Hemiarthroplasty

Hemiarthroplasty (Fig. 5) of the TMC joint is a recent and relatively novel procedure in comparison with other TMC implant arthroplasties. The procedure consists of insertion of a prosthesis into the metacarpal while a socket (instead of a separate prosthesis as with the total joint and SRA) is created in the trapezium. Two common hemiarthroplasties include the pyrocarbon and BioPro Modular Thumb prosthesis.[32,33]

Initial results of TMC joint hemiarthroplasty have been encouraging.[32,33] Pritchett and Habryl[33] reviewed 159 TMC joint BioPro Modular hemiarthroplasties with average follow-up of 72.1 months, finding patients achieved predictable pain relief, improved pinch and grip strength, satisfactory appearance of their thumb, and satisfaction with the procedure. Complications were limited and included 1 intraoperative fracture, 1 painful neuroma, and 1 infection. The development of trapezial concavitiy deepening was also noted in 7 patients, with the majority of deepening occurring during the first postoperative year. Survival analysis showed a survival rate of 94% at 72 months. Likewise, Martinez de Aragon et al[32] observed pain relief, improved strength, and satisfaction using the pyrocarbon hemiarthroplasty; however, more complications (27%) were observed, including subluxation (n = 10), iatrogenic implant damage (n = 1), scaphotrapeziotrapezoid arthritis (n = 1), and loosening (n = 3). The 22 month implant survival rate was 80% with revision or trapeziectomy as the end point.

DISCUSSION

Implant arthroplasty (Fig. 6) is able to produce a pain-free joint with reasonable motion and function in the setting of PIP, MCP, and TMC joint arthritis. However, these arthroplasties have historically been associated with high rates of complications, including implant loosening, joint instability, and in some settings, loss of joint motion. There remains a paucity of high-quality studies prospectively analyzing the outcomes of these procedures because most of the available literature consists of case series. Furthermore, aside from the Daecke et al study,[14] there are very few head-to-head comparisons between specific types of procedures or implants. Whereas recent innovations have shown promise, there remains a critical need for future investigation to refine and improve surgical techniques, implant technology, and understanding into why complications and factors associated with them occur. This is particularly important in defining the role of implant arthroplasty as a treatment for basilar thumb arthritis, including a comparison with ligament reconstruction tendon interposition or other well-established treatments.

SUMMARY

In summary, in the management of PIP OA, silicone remains the gold standard. Despite its poor ability to correct coronal plane deformities, the survivorship and pain relief and patient satisfaction scores compare favorably with the other implants. The SRA implant has demonstrated good medium-term survivorship and outcomes. The use of cement and avoidance of the volar approach in these cases has been shown to improve outcomes. Pyrocarbon remains controversial with mixed outcomes and higher reoperation rates than those of silicone and SRA implants. Despite favorable reports with the use of SRA implants for RA of the PIP joint, the authors prefer the use of silicone in this patient group.

With respect to MCP arthritis, silicone remains the gold standard for RA. Little if anything can be concluded about SRA implants for the MCP joint. Pyrocarbon has demonstrated good results in patients with OA, and is currently the authors' treatment of choice for the osteoarthritic MCP joint.

The TMC joint implant arthroplasty has failed to demonstrate superiority over biological interposition and/or suspension arthroplasty, and at this point, there is no obvious indication for their use in the management of basal thumb arthritis.

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EDITORS' SUGGESTIONS FOR MORE INFORMATION

The Editor chose to include these references and videos to provide readers with additional information.

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JOURNAL CME QUESTIONS

Implant Arthroplasty for Proximal Interphalangeal, Metacarpophalangeal, and Trapeziometacarpal Joint Degeneration

1. With regard to silicone proximal interphalangeal (PIP) arthroplasty, which of the following is the most likely long-term benefit?

a. Improved total arc of motion
b. Pain reduction
c. High rate of revision
d. Poor patient satisfaction
e. Deformity correction

2. A worrisome, recently reported complication in as many as 48% of PIP pyrocarbon implant arthroplasties has led some to abandon this implant at the PIP joint. Which of the following is the complication?

a. Squeaking
b. Implant fracture
c. Loss of motion
d. Implant migration
e. Dislocation

3. In large study cohorts, silicone metacarpophalangeal (MCP) joint implant arthroplasty has which of the following 10-year survival rates?

a. 100%
b. 80%
c. 60%
d. 40%
e. 20%

4. With use of the pyrocarbon basilar thumb joint hemiarthroplasty, the most frequent postoperative complication reported is which of the following?

a. Subluxation
b. Squeaking
c. Metacarpal fracture
d. Implant breakage
e. Loosening

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