The BioPro Thumb Carpometacarpal Hemiarthroplasty: Case Series and Surgical Technique

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Abstract: Thumb carpometacarpal (CMC) osteoarthritis is painful and debilitating. Here, we explore outcomes of a modular, press-fit thumb CMC hemiarthroplasty prosthesis (BioPro). This surgical option permits minimal bone resection, sparing the trapezium, hence allowing revision options if necessary. A retrospective review of all cases of the modular thumb CMC implants performed at one community US center between 2018 and 2021 were included and invited for email or telephone review. Electronic records were examined for demographics, patient outcomes, and morbidity. Eleven patients underwent 11 thumb CMC joint hemiarthroplasties, mean age was 64.8 years (SD: 7.68 y), with 6 females. Six received surgery on their dominant extremity. Two were manual workers (both in the medical field), 6 office-based, 2 retired, and 1 homemaker. The preoperative median pain score (Visual Analog Score) was 8/10 (range: 5 to 10), reducing to 1/10 (range: 1 to 10) ($P = 0.000033$) with a median follow-up of 23 months (range: 13 to 39 mo). In all, 8/11 patients reported they would recommend this surgery to friends and family and opt for the same surgery on their contralateral hand if necessary. One patient reported persistent pain a year postoperatively. On review, the head of the implant was placed too deep into the trapezium. Another center found that this patient had a postoperative trapezium fracture and underwent revision with implant removal and conversion to a suspension arthroplasty. At 12 months, 10/11 thumb CMC hemiarthroplasty showed good pain relief, function, and patient satisfaction. The BioPro has a low risk of subluxation and allows salvage options to remain available should failure occur.

Key Words: base of thumb arthritis, arthroplasty, CMCJ

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The thumb carpometacarpal (CMC) joint is the second most commonly affected site of osteoarthritis in the hand,[1] and is incapacitating due to loss of dexterity limiting daily living and work. Arthritic patients may present with thenar pain, pinch weakness, and CMC crepitus on a grind test.[1,2] Treatment options include nonoperative measures such as anti-inflammatories, injections, physical therapy, and bracing, and operative interventions such as arthrodesis, arthroscopy, trapeziectomy, and total joint arthroplasty. A trapeziometacarpal (TM) fusion offers a young active patient such as a manual laborer a reliable operation preserving pinch strength.[3] However, arthrodesis transfers mechanical stress to surrounding arthritic joints and limits patient dexterity, unable to place their hand on a flat surface.[3,4,5–7]

Arthroscopic options for definitive surgery of thumb metacarpal joint osteoarthritis include a metacarpal osteotomy in stage II disease, or arthroscopic hemitrapeziectomy for stage III, but may still require cast immobilization postoperatively.

The most common surgical treatment of CMC arthritis is a trapeziectomy and ligament reconstruction and tendon interposition (LRTI).[1,2] Although effective at mitigating pain, concerns persist for thumb shortening, subluxation, and decreased pinch strength.[3] Revision LRTI may be considered for metacarpophalangeal hyperextension, functional decline, graft displacement, tendinitis, and continued pain or notably, scaphotrapezoid arthritis.[4] However, functional and pain outcomes after revision LRTI are poorer than primary surgery.[4] This may be attributed to thumb subsidence, caused by the loss of the trapezium's support. Therefore, if symptoms persist in a patient who has undergone a primary LRTI procedure, few good salvage options are available.

Since the 1970s, different types of prosthetic implants have been developed, to maintain thumb length and function but have demonstrated varied results. Silicone implants popularized by Swanson have now fallen out of favor, as the pain relief and recovery of function was transient. Moreover, these patients were prone to subluxation, instability, fragmentation, height loss, and most significantly, silicone synovitis.[4–7] Other materials such as pyrolytic carbon and titanium still led to detrimental complications such as subluxation, implant loosening, and metacarpal cortical erosions.[8,9] Press-fit total joint implants are still not cleared by the Food and Drug Administration (FDA) for press-fit use, therefore, complications related to cement use remain an issue, particularly when considering revision surgery.

The BioPro Modular Thumb (BioPro) is a 2-piece thumb basal joint implant designed for cementless hemiarthroplasty in patients with CMC arthritis. The press-fit plasma-sprayed stem has a varus angulation that mimics the anatomic orientation of the CMC joint. In addition, the modularity allows for 48 implant combinations, fitting a wide range of anatomy. A study by Pritchett[10] demonstrated that 135/159 thumbs were rated as "good" or excellent postoperatively. One hundred thirty-eight thumbs had "no," or only "occasional" pain. Overall, 139 had "good" or "excellent" functional improvement, and 142 had "good" or "excellent" cosmetic appearance with an average of 72.1 months' follow-up (range: 35 to 120 mo). There was a 1.5 kg increase in average pinch strength from preoperatively. Eleven subjects had undergone an LRTI on the contralateral thumb, and all 11 patients preferred the hemiarthroplasty over an LRTI.[10]

In Pritchett's[10] study, reported complications included 1 intraoperative fracture, 1 neuroma, 1 infection, and 6 were revised to another BioPro implant. Revisions were mostly because of stem loosening due to the failure of bone ingrowth. It should also be noted that there were only 2 subluxations (1.3%) in contrast to up to 35% subluxation seen with other implant materials.[10,11] This high success rate may be attributed to the preservation of trapezium. Since the trapezium is preserved, the thumb length, pinch strength, and cosmetic appearance can be maintained. Another advantage of thumb

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hemiarthroplasty is that because the trapezium is preserved, the implant can be removed and revision to an LRTI is possible, if necessary.[2]

INDICATIONS AND CONTRAINDICATIONS

A press-fit hemiarthroplasty procedure maintains much of the bone stock of the diseased joint; therefore, salvage options are available should failure occur. The typical barometer for "indication" is patient age, however, we note that activity level is more important. While golfers and other recreational sportspeople have been candidates, we tend to reserve this implant for patients in their 60s, but younger patients may be candidates if they have fewer demanding occupations or hobbies. There is no firm age endpoint for implant consideration, but a frank discussion with the patient is needed. Repetitive heavy gripping or pinching are relative contraindications.

Patient anatomy is crucial since the trapezium needs to have sufficient width and height to accommodate the hemispherical head implant. Spherical broaching of the trapezium is done after an initial trough is created by a burr. One of our subluxation complications likely occurred due to inadequate trapezial height and this should best be assessed by a Robert's view radiograph. Preoperatively, the surgeon needs to assess the minimum trapezium size to seat the implants hemisphere, with an adequate cortex to avoid fracture around the implant head. A thorough assessment of peritrapezial anatomy with office fluoroscopy in multiple oblique views is suggested.

A hemiarthroplasty will not address significant scapho-trapezial-trapezoidal (STT) arthritis. However, this is not an absolute contraindication since many patients have minor osteoarthritis changes in the STT joint that are not symptomatic. STT tenderness can be confirmed on palpation. Unless the STT joint space loss is major, pain can be assessed by palpation over the joint, at the base of the first webspace, and confirmation with a lidocaine test injection, best placed by fluoroscopic control. If major improvement of symptoms occurs, one should lean away from recommending a CMC arthroplasty as complete trapezial excision is likely needed. Some authors have recommended trapezial excision of both the TM joint and the scaphotrapezial interface. Cobb et al[12] has done this via arthroscopy of both joints and then performing simultaneous burring arthroplasties.

In Pritchett's study from the design center, there was a 94% implant survival at 6 years.[10] A separate center reviewed the outcomes of the BioPro implant demonstrating a 61.5% (16/26) revision by 12 months.[13] Here, we discuss the surgical technique and report our case series outcomes, outside the design center.

TECHNIQUE

Similar to most thumb arthroplasties, the hemi-implant can be done with simply regional block anesthesia, and a tourniquet is used for good visualization.

A simultaneous first compartment release is important; therefore, the surgical approach is just distal to the usual incision site for DeQuervain's release, on the direct radial side of the wrist with forearm in neutral position. The author (A.B.) prefers a curvilinear lazy-S incision since this allows for broader exposure and is more aesthetically pleasing (Fig. 1). It is important to ensure that a subcompartment for the extensor pollicis brevis is released if present. Identification and careful protection of any visible branches of the superficial radial nerve is critical.

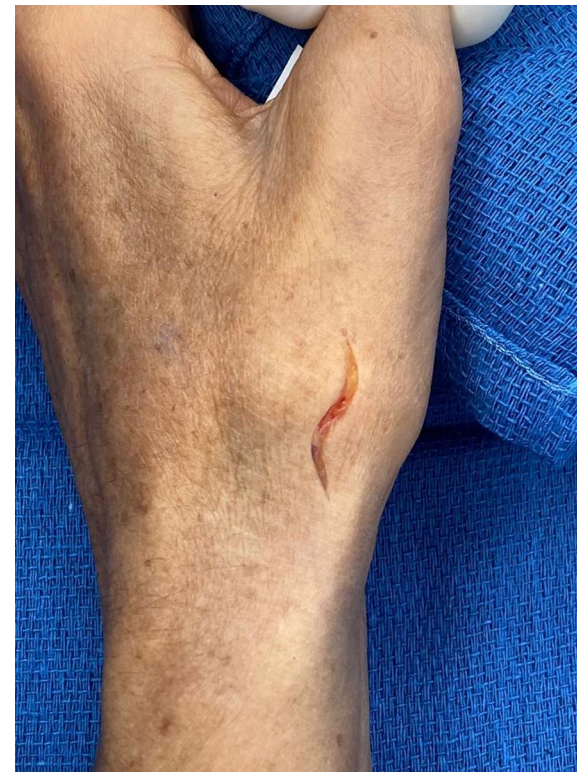

FIGURE 1. Curvilinear lazy-S incision markings.

The approach to the TM joint is between the extensor pollicis brevis and abductor pollicis longus (APL), being careful to avoid the dorsal branch of the radial artery since it typically crosses this field at the level of the scapho-trapezial joint (Fig. 2). It is helpful to plan for later capsular closure when performing an arthrotomy as the capsule provides additional stability. The author prefers a T-shaped incision where the transverse portion of the capsule is peeled off the metacarpal base including the broad attachment of the APL. The longitudinal portion of the approach is directly over TM joint and the dorsum of the trapezium. At this point, any dorsal osteophytes are removed and the dorsum of the broad base of the first metacarpal is amply exposed. A periosteal elevator is used to expose the proximal 1.5 cm of the metacarpal also allowing the placement of small Hohmann retractors on either side. A precise cutting guide facilitates the 10-degree back-cut of the metacarpal base, although it requires a larger incision to accurately place (Fig. 3). As the surgeon technique evolves, the guide can be used as an approximate reference as to where and how to make a cut with the sagittal saw. The accepted technique calls for a 6 to 8 mm resection of the metacarpal base, but due to the dorsal proximal flare of the thumb metacarpal, the saw cut must be at ~1 cm from the metacarpal base. Thick capsular and ligamentous attachments must be freed up with sharp dissection, being careful not to cut the flexor carpi radialis, as the resected base is excised. Traction on the thumb is maintained by the surgical assistant to best visualize the interval and resect the redundant palmar capsule including the usually critical volar oblique ligament. This step is critical since the surgeon must ascertain how deep the ulnar limit of the trapezium lies. A common technical pitfall is to ream the trapezium much too dorsally, hence not maintaining enough dorso-radial wall to support the implant head in the

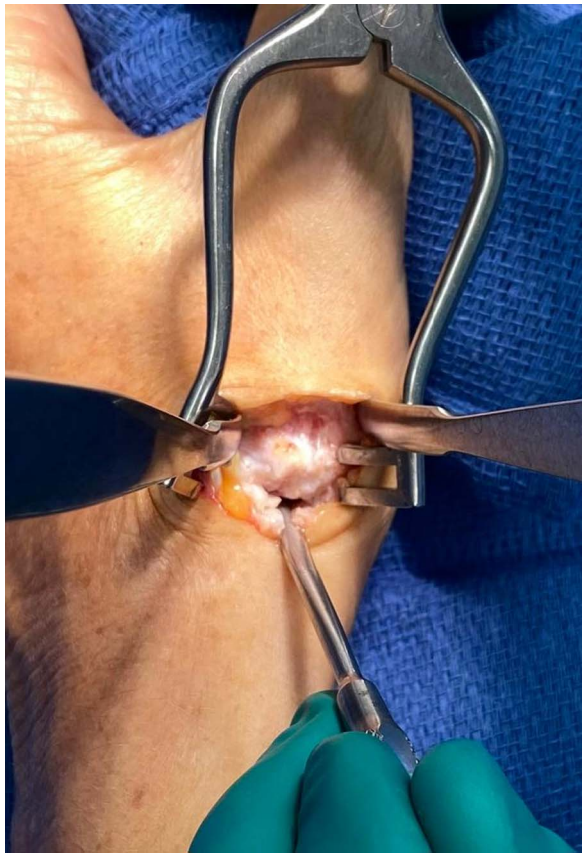

FIGURE 2. Trapeziometacarpal joint between extensor pollicis brevis and abductor pollicis longus.

trapezial trough. Deep exposure of the trapezium with an elevator is a critical step. Once the margins of the trapezial bone are defined, any deep osteophytes including the ulnopalmar spur, are removed often requiring the saw and small osteotome. This will allow the implant to be seated centrally enough in the trapezium. That process is started with a high-speed round burr, typically 4mm, irrigating and suctioning out bone fragments meticulously to maintain good visualization as this represents the most critical step of the procedure (Fig. 4). A coarse rasp from the BioPro hemimodular tray is then used to serially ream the trapezium, creating a trough that will accept the implant. Once a good fill is achieved, the fine rasp is used of the same size diameter. The spacer guide is now inserted of the appropriate diameter, with 0, +2, and +4 gradations (Fig. 5). The offset will be dictated by how much metacarpal base was resected, and patient ligamentous laxity. The trial spacer should sit stably and allow for good thumb circumduction. Slight pistoning is possible and is acceptable.

Once selected, the cut metacarpal base is brought to the surface of the approach by adducting the thumb maximally, often helped by placing an elevator deep under the metacarpal. Serial broaching of the metacarpal base is done, initially by hand, then with the assistance of a mallet as the spongy bone readily accepts the reamers until the correct size is encountered, usually limited by the ulnarward flare of the metacarpal component as it sits up against ulnar cortex of the metacarpal proximal shaft. This helps provide stability with the collar sitting flush against the metacarpal base cortex if the initial cut was made at the optimal angle.

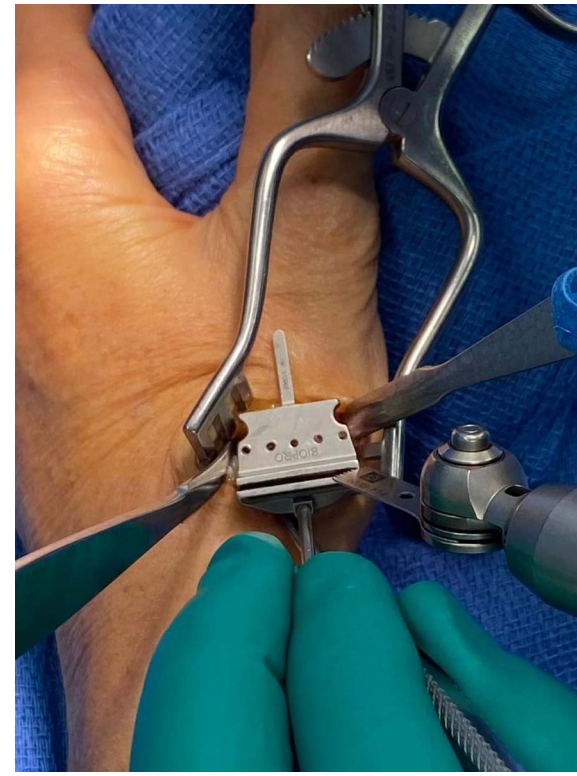

FIGURE 3. Proximal metacarpal cutting guide placement and resection.

Once the metacarpal and trapezial surfaces have been prepared, irrigation is done, and the trial implant components are selected. The corresponding head with offset is impacted onto the selected stem and then placed into the broached metacarpal. Reduction of the head into the trapezial trough should reveal a stable joint with exception of extreme adduction where slight subluxation may occur. Pistoning to a mild degree is acceptable but excessive looseness of the implant reaching 50% of the trough depth will warrant a step up in the offset. Fluoroscopy is then brought in to show good fill of the trapezium

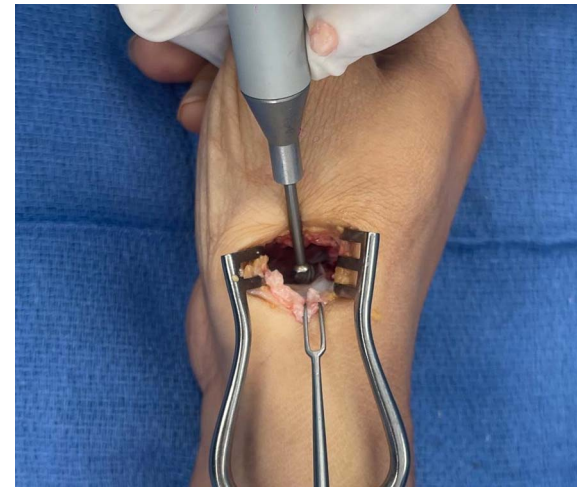

FIGURE 4. Exposure of trapezium and burring.

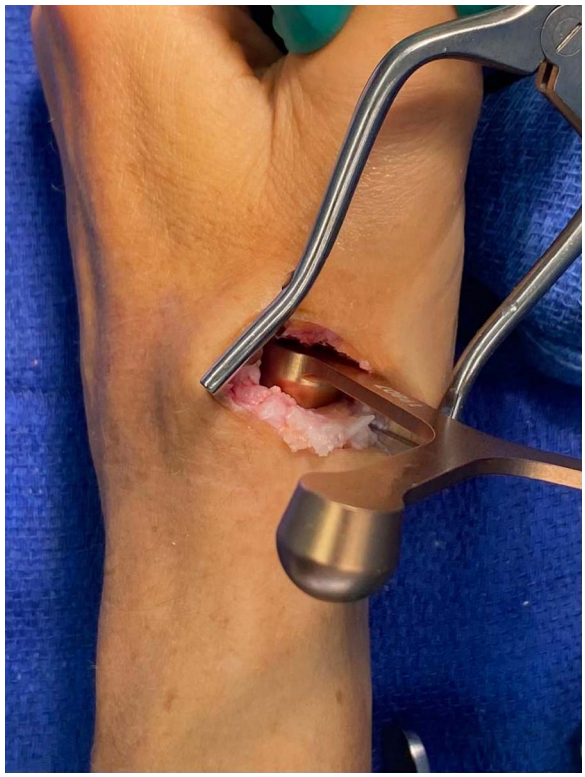

FIGURE 5. Spacer guide in place.

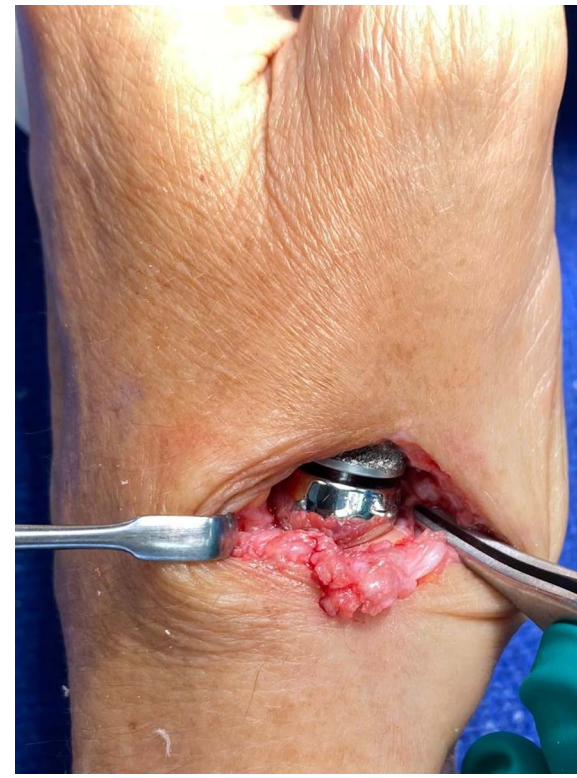

FIGURE 6. Implant in situ.

and functional motion under dynamic fluoroscopy with no instability of the head-carpal junction.

If the trial component is deemed stable and with good motion, the definitive implants are opened, the head is impacted on the stem Morse taper and then inserted with the impactor to ensure maximum press-fit (Fig. 6).

Final range of motion and stability are assessed grossly and by live dynamic fluoroscopy.

The capsule is closed with an absorbable suture which will incorporate the APL insertion and lend further stability. The skin can be closed with surgeons' preference of skin sutures, and a sterile dressing is applied, followed by a short thumb spica plaster splint that is custom molded, and the tourniquet is released. Strict elevation of the hand is maintained en route to, and in, the recovery room.

POSTOPERATIVE MANAGEMENT

The patient and family are advised to maintain strict elevation of the hand above the heart, although light activities of daily living can commence the next day. Active full digital motion should be started immediately, and the thumb interphalangeal joint is also free to move. On day 5 postoperatively, the splint is removed, the wound is checked, and an x-ray confirms good position of the implant, and therapy is commenced. Patients are then placed into a hand-based thumb spica plastic splint that should be worn at most times during the initial 3 to 4 weeks, except for therapy sessions, as well as home exercises which are prescribed for daily progress. No passive range of motion is done, and once edema diminishes, active-assisted range of motion is commenced, with clear communication to the therapist that cross-palm adduction of thumb to the base of the small finger is unnecessary and highly discouraged. This can exacerbate capsular pain and potentially promote instability. Gentle pinch strengthening usually begins within several weeks depending on patient progress. Most of the strength is regained months later by a continued home program that the patient is instructed in. Splint usage is strongly recommended even many months later when any vigorous activities are performed, whether home, in sport/hobby, or work activities.

METHODS

All patients undergoing a Modular Thumb CMC hemiarthroplasty between 2018 and 2021 at a single community center in the United States were included and invited for email or telephone review. Ethical approval was given by our institution. Subjective data was collected such as pain level preoperatively and postoperatively, limitation of activities of daily living, job performance, and housekeeping abilities, duration for thumb to feel back to "normal," and the likelihood of recommending surgery to others or opting for same surgery on the contralateral thumb.

RESULTS

There were 11 patients who underwent 11 thumb CMC joint hemiarthroplasties. The mean patient age was 64.8 years old (SD: 7.68 y), and the cohort consisted of 5 males and 6 females. Six received surgery on their dominant extremity. Two patients were manual workers (both in the medical field), 6 were office-based, 2 were retired, and 1 was a homemaker.

Preoperatively, the median pain score (Visual Analog Score) was 8 out of 10 (range: 5 to 10), which was reduced to 1 out of 10 (range: 1 to 10) ($P = 0.000033$) with a median follow-up time of 23 months (range: 13 to 39 mo) (Fig.7). Eight out of 11

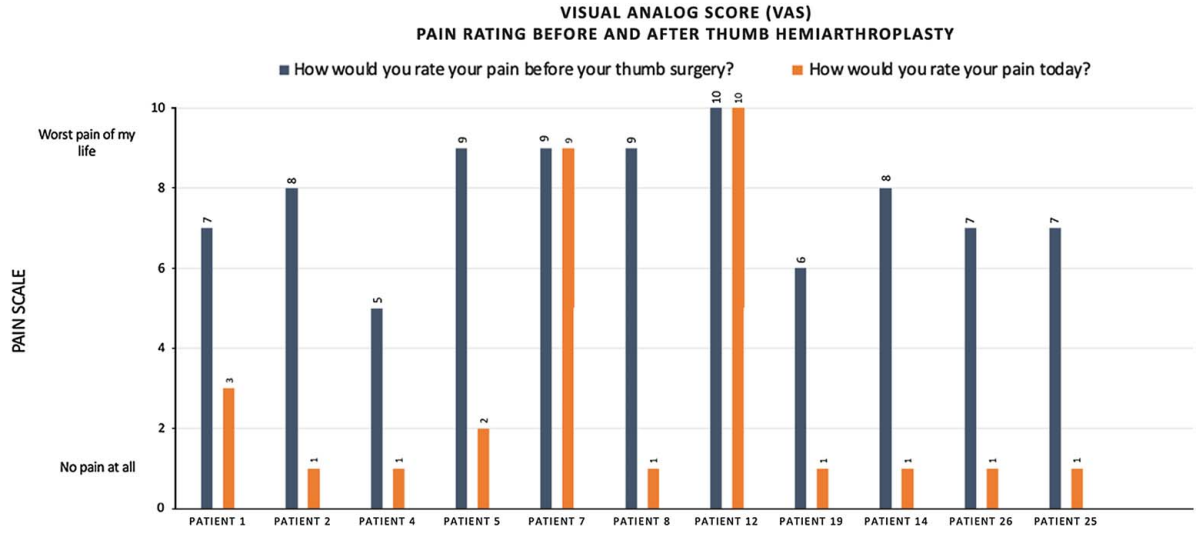

FIGURE 7. Visual Analog Score.

patients reported that they would recommend this surgery to their friends and family as well as opt for the same surgery on their contralateral hand if necessary. Two of 11 patients have since had the same procedure performed on the contralateral hand.

One patient (patient 12) reported persistent pain a year postoperatively. On review, it was determined that the head of the implant was placed too deep into the trapezium (Fig. 8). At a different center, this patient was found to have a postoperative trapezium fracture and thus underwent a revision with the removal of hardware and conversion to a suspension arthroplasty. She reports an 80% return of strength 1 year after suspension arthroplasty.

DISCUSSION AND EXPECTED OUTCOMES

Here, we present our results outside of the index center on experience with a thumb hemiarthroplasty modular system.

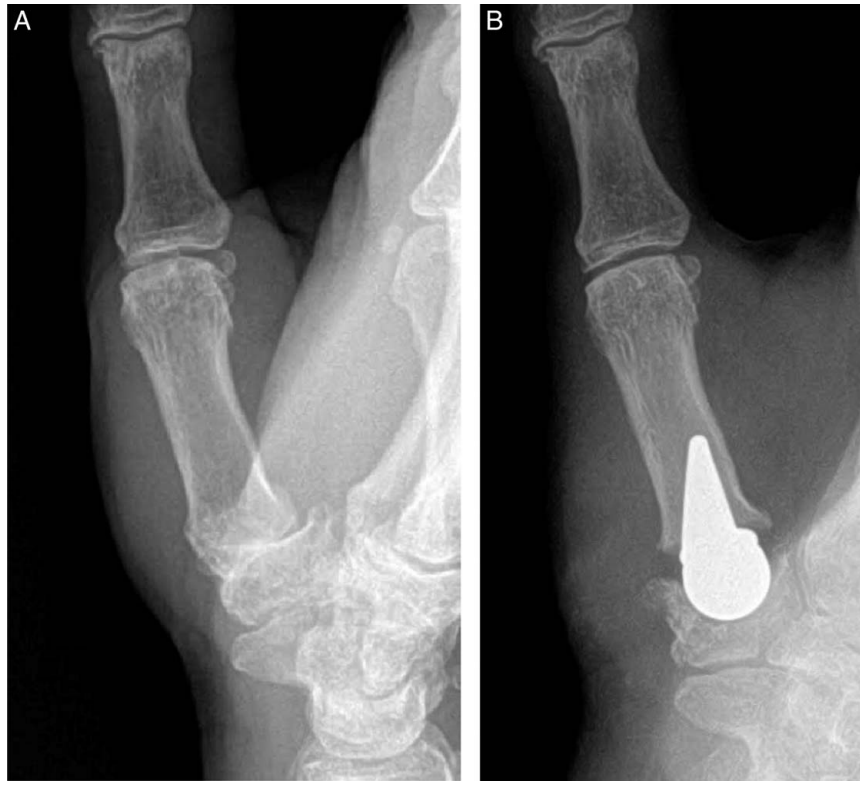

FIGURE 8. A, Preoperative radiograph demonstrating thumb carpometacarpal joint osteoarthritis. B, Postoperative radiograph demonstrating BioPro implant.

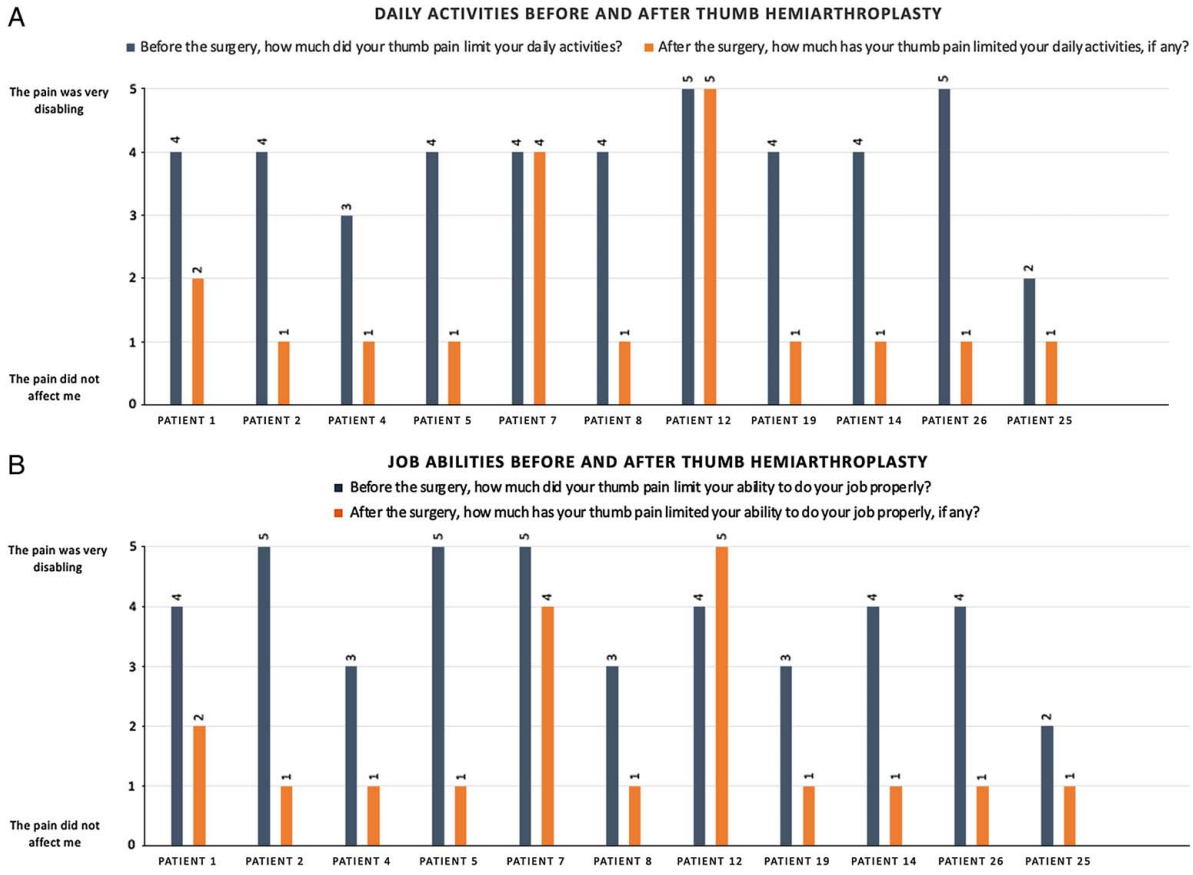

FIGURE 9. Patient reported functional outcomes with activities of daily living (A) and occupation (B).

Thumb hemiarthroplasty is a relatively newer and less popular mode of treatment of CMC joint degeneration. Early follow-up in our case series demonstrates good outcomes with restoration of function and excellent patient satisfaction. Currently, the most common surgical treatment is trapeziectomy with LRTI; however, complications such as joint instability, tendon ruptures, and pain remain.

At our center, thumb basal joint hemiarthroplasty with BioPro modular implants is the preferred method of treating CMC joint arthritis, especially in older patients with less physical demands. Our patient cohort experienced a noticeable improvement in their function (Fig. 9) and pain levels after undergoing thumb hemiarthroplasty. There is a possibility that patients will continue to use a splint to perform any heavy work activities for several months, which can be a drawback for many.

The hemiarthroplasty, if necessary, can be converted to a trapeziectomy by removal of the implant with augmentation with a LRTI or alternative technique, for example, in the case of patient 12. Here, this patient was found to have post-operative trapezium fracture and a subsequent proximal migration of the modular head. As her trapezium was preserved, the patient had various salvage options and was converted to a trapeziectomy and standard suspensionplasty at a different institution.

Our study is a validation of previous work outside the originating design center, showing good outcomes at 12 months.[2,10,11] In contrast to the study by Marinello et al,[13] only 1 of 11 cases in our study required revision by 12 months.

LIMITATIONS

Our case series has some limitations. A longer follow-up and larger sample size would be indicated to assess the longevity of the prosthesis and long-term patient satisfaction. In addition, all hemiarthroplasties were performed at a single institution by a single hand surgeon highly experienced with BioPro modular implants. Therefore, our data may not reflect the results of the general orthopedic hand surgeon population. We note that patients' experience of their procedure may be subject to recall bias, which requires a prospective cohort study or randomized control trial to rectify.

CONCLUSIONS

The BioPro Modular Thumb Implant is a reliable alternative to the current standard surgical management of basal joint thumb arthritis. Our preliminary data demonstrates high patient satisfaction and successful functional outcomes. In addition, a significant advantage of thumb CMC joint hemiarthroplasty is that it can be easily revised into conventional surgical treatments should it fail, as the trapezium is preserved.

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