Intraoperative Fracture of a Pyrocarbon PIP Total Joint—A Case Report

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Abstract Pain or dysfunction of the finger joints due to arthritis or traumatic injuries that fail medical management may necessitate arthroplasty or joint replacement. The goals of the finger joint implant arthroplasty are to relieve pain, to correct deformity, and to improve the function and appearance of the hand. Several prosthetic implants have been used for the replacement of the proximal interphalangeal (PIP) joint. Pyrocarbon materials, a form of pyrolytic carbon, a ceramic-like material, have proven to be strong, durable, resistant to wear and nonreactive in the body. The Ascension PIP pyrocarbon total joint is a bicondylar, anatomically shaped, articulating implant that allows joint flexion–extension, while providing some restriction of adduction–abduction motion. A review of the literature of pyrocarbon PIP prosthesis reveals little clinical data. The case of a 33-year-old man with posttraumatic arthritis proximal interphalangeal joint right long finger is reported. The case was treated surgically using the Ascension PIP total joint. During the insertion of the implant, the proximal component fractured at the sub-articular collar. The component was removed, and a new implant was inserted without complication. Critical evaluation revealed that there was an inadequate resection of the volar lip resulting in a stress riser on the implant during impaction. Careful attention to this technical point will hopefully minimize the occurrence of this complication as the availability and use of these implants increases.

Keywords Proximal interphalangeal joint · Proximal interphalangeal joint prosthesis · Ascension PIP total joint

Introduction

Small joint arthroplasty is indicated for posttraumatic arthritis, degenerative joint disease, and rheumatic arthritis. A review article revealed advantages and disadvantages of small joint arthroplasty considering all the aspects of prosthesis such as range of motion, stability, biocompatibility, strength, wear, and soft tissue reconstruction [7]. The author mentions that total joint designs better simulate normal joint function, but also notes that implant loosening and breakage have been reported.

Historically, silicon finger joint implants have reliably provided pain relief; however, they have relatively high rates of complication. These include implant fractures, silicone synovitis, destructive bone changes, and dislocation. Over the past three decades of clinical use, pyrolytic carbon has proven to be biocompatible and have minimal wear with in vivo use [5, 10]. In comparison to silicon implants, pyrocarbon finger joint implants offer biological compatibility, low wear rates, and durability, while providing pain relief and improving the arc of motion. Pyrocarbon implants also have the potential for long-term survival because it is a biologically inert polymer and has an elastic modulus better matched to bone compared with alternative replacement materials for the MP and PIP joints [2–4].

We report a case of a 33-year-old man with an intraoperative implant fracture, and we describe a technique for removal and stress the careful evaluation of the bone surfaces before final implantation to avoid this complication.

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Case Report

This is the case of a 33-year-old man with posttraumatic arthritis of the proximal interphalangeal joint right long finger. He sustained amputations to both ring fingers at the proximal phalanx level. Along with that, he had an open comminuted fracture of the long finger proximal phalanx. He had undergone several procedures for nonunion, and subsequent mal-union of the proximal phalanx, and ultimately developed posttraumatic arthritis of the proximal interphalangeal joint. The PIP joint was stiff, slightly angulated, and painful. To maximize hand function, a proximal interphalangeal joint arthroplasty was performed. The patient was also offered a ray transfer of the small finger to close the inter-digital gap; however, this was refused. A preoperative x-ray of the PIP joint is depicted in Fig. 1.

The previous dorsal surgical incision over PIP joint was used. The extensor mechanism was split longitudinally in the midline and elevated both radial and ulnar to expose the PIP joint. Bone resection and preparation were performed as described by the manufacturer's technique. Both the proximal and distal phalanges were broached to a size 40 without difficulty. The volar lip of the proximal phalanx was resected using the volar cutting jig and an oscillating saw.

Before insertion, two drill holes were made in the base of the middle phalanx entering the medullary canal. A 4-0 Vicryl suture was passed through the extensor tendon, basically at the central slip insertion from outside through the hole and then out so that we could anchor the central slip to the bone during closure. The middle phalanx component was impacted in place first. The proximal

phalanx component was impacted into place similarly. The joint was stable to both varus and valgus stress, and the joint was thought to be stable with motion. When the mini C-arm images were obtained to check the implant position, we noticed a crack at the neck of the proximal implant. Figure 2 shows the broken implant.

The articular portion of the implant was easily removed; however, attempts to remove the stem were unsuccessful and created particulate debris. We took the small round burr from the implant set. Under C-arm guidance, we localized the proximal end of the stem, and a 2- to 3-mm burr hole through the dorsal cortex was created. Using the hook of a small Hohmann retractor, we were able to get into the intramedullary canal and push the stem out far enough to retrieve it with a needle driver. There was some debris within the canal, which was irrigated out thoroughly. Figure 3 shows implant removal.

The trial component was reinserted, and critical evaluation revealed incongruent bone contact against the volar edge of the component resulting in a stress riser on the implant during insertion. After additional resection of the volar edge of the proximal phalanx, a second implant was impacted without complication. The joint was reduced, had 90° motion and was stable in all positions. Final mini-C-arm images showed both components properly placed and in good position.

At 6 weeks postoperatively, the patient exhibited 0 to 90° range of motion, with a 20° active extension lag, no residual angular deformity. Radiographs showed appropriate position of the implant with no evidence of loosening or change in position. Figures 4 and 5 show the antero-posterior and lateral x-rays at 6 weeks postoperatively.

Figure 1 Preoperative radiograph of the PIP joint.

Figure 2 Broken implant.

Figure 3 Implant removal.

Discussion

Pyrocarbon PIP implants offer distinct advantages over arthrodesis and silicone joint arthroplasty in patients with posttraumatic, degenerative, and rheumatologic arthritis. Several clinical articles discussed pyrocarbon PIP joint implants demonstrating that they reliably reduce pain, improve range of motion, and are functionally superior to arthrodesis [3, 6, 8, 9, 11, 12]. One disadvantage is that, by its nature, pyrocarbon is brittle and susceptible to breakage during impaction. To date, there are few clinical results related to PIP pyrocarbon implants, and no reports of intraoperative complications in the literature.

Preclinical studies have been performed by Ascension Orthopaedics Inc including: mechanical testing of Ascension PIP components, finite element analyses of Ascension PIP contact stress, biocompatibility testing of the pyrocarbon material. All preclinical studies revealed that the Ascension PIP is capable of supporting functional joint motion and grip and pinch strength for the long term. Finite element stress analysis (FEA) was conducted to determine the contact stresses in the Ascension PIP device. These contact stress analysis results together with endurance test results demonstrate that the Ascension PIP is capable of supporting a biomechanically demanding load in the long term without sustaining damage to the articulating surface [1].

The clinical results reported by Ascension Orthopaedics for pyrocarbon metacarpophalangeal (MCP) implants reveal a fracture rate of 1.4% (4/295) overall. All intraoperative fractures of that implant were managed uneventfully, and no sequelae resulted.

This is the first reported case of a PIP implant which was broken during insertion. In our patient, we believe that the implant fracture occurred because of insufficient volar bone resection at the proximal phalanx. Although there was some deformity within the proximal phalanx and a metallic

Figure 4 Six weeks postoperative antero-posterior radiograph of the PIP joint.

fragment from prior fixation, the broach was fully seated within the intra-medullary canal during preparation. Premature contact of the implant with the volar cortical bone results in the bending moment on the implant during subsequent impaction. The bending moment is localized to the interface of the stem and the articular portion of the component which is a natural geometric stress riser. Once component was removed and the volar resection revised, the second implant was inserted without difficulty and was stable.

When implanting these components, we recommend careful inspection of the resected bone surfaces during insertion of the trial components to reduce the risk of implant fracture and additional expense. Should this complication occur, we also described our technique for removing the broken implant stem through the use of a

Figure 5 Six weeks postoperative lateral radiograph of the PIP joint.

proximal cortical window to push the stem out. Our initial attempts at grasping the exposed portion of the stem were unsuccessful and only resulted in the creation of particulate debris.

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