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Proximal interphalangeal joint replacement with an unconstrained pyrocarbon prosthesis (Ascension®): a long-term follow-up

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Abstract

There have been limited publications that report long-term outcomes of pyrocarbon implants. This report describes both clinical and radiographic long-term results for patients who have been treated with pyrocarbon proximal interphalangeal implants. Thirteen implants in ten patients are reported for an average follow-up of 8.3 years (range 6.2–9.3). All patients were suffering from degenerative joint disease. Five of the 13 digits were free of pain, the remaining eight digits had mild to moderate pain (visual analogue scale 2–5). The average active range of motion was 58° (SD 19°) at latest examination. X-ray results were unremarkable in six digits with an acceptable position of the prosthesis. However, in seven patients significant radiolucent lines (≥ 1 mm) were observed. Three prostheses demonstrated a migration of the proximal component, and one a subsidence of the distal component. Our study does not support the use of this implant for treatment of osteoarthritis of the finger joint owing to high complication rates and limited range of motion.

Keywords

Finger joint, prosthesis, pyrocarbon, arthritis

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Introduction

Joint replacement of the proximal interphalangeal (PIP) joints for degenerative or post-traumatic arthritis is an alternative to joint arthrodesis and silicone arthroplasty. Early constrained and semi-constrained prosthesis designs were abandoned owing to high rates of loosening, implant breakage and an insufficient postoperative range of motion (ROM) (Deb et al. 2003; Brannon and Klein, 1999).

Silicone arthroplasty has been accepted as an alternative to these failed designs. However, restricted ROM, bone loss, implant breakage, loosening and joint instability are associated with silicone implants (Deb et al., 2003; Kleinert and Lister, 1986; Swanson et al., 1985; Takigawa et al., 2004).

PIP resurfacing arthroplasty utilizing metal–plastic and pyrocarbon implants is the current alternative to silicone implants for the finger. Pyrocarbon implants (graphite core with carbon exterior) are designed to imitate natural anatomical geometry. The design intention should result in appropriate implant alignment and kinematics, without excessive stresses transferred to the fixation in the host bone. Components are press fit eliminating the need for cement. Four sizes are available (10, 20, 30 and 40), with some flexibility of size matching between the distal and proximal components. The proximal and the distal component sizing can be 'mismatched' with the limitation that a pair must be no more than one size up, or one size down from the adjacent side.

Early short-term publications indicated promising results regarding PIP pyrocarbon joint prostheses (Cook et al., 1999; Heers et al., 2006; Meier et al., 2007; Schulz et al., 2005). However significant radiolucent lines surrounding the prosthesis (≥ 1 mm) were observed. This was understood to be somewhat expected, owing to the carbon surface of the implant not osteointegrating to the bone (Daecke et al., 2006).

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Studies that reported mid-range results with the procedure describe decreased ranges of motion as well as a significant percentage of complications including implant migration and loosening (Sweets and Stern, 2011).

Long-term results are lacking for the procedure. In this article we describe both clinical and radiological results for a group of patients who have had the procedure in which the arthroplasty has survived over an average of 8 years.

Methods

Between the years 2002 and 2005, 17 PIP joint replacements made from pyrocarbon (Ascension®) were implanted in 14 patients. Those patients with inflammatory and post-traumatic arthritis were excluded from the group reported in this study. In addition, collateral ligaments had to be intact. All fingers had no history of previous operations.

All patients had symptoms for over 10 years and had resigned not to expect any future relief of symptoms. Prior management of the condition consisted of physical therapy and non-steroidal anti-inflammatory drugs (NSAID). Of the 14 patients considered, ten (13 implants) were available for follow-up and were assessed for active ROM, pain (visual analogue scale (VAS); range 0–10), complications, and radiologic findings assessed from posterior–anterior and lateral views of the finger. Four patients were not available for follow-up. One patient had died, another patient was suffering from a stroke and two patients were not satisfied with the treatment and refused any further evaluation (including radiographs) without giving specific reasons. Both of these patients did report no revision surgery.

Posterior–anterior and lateral radiographs of the finger were done within 2–3days postoperatively. These radiographs were compared with those taken at the time of the last follow-up for each patient.

A periprosthetic lucency of 1 mm and more was considered significant when assessing radiographs. It should be noted that a periprosthetic lucency of 0.5 mm is a normal finding for these implants owing to the radio-lucent pyrocarbon coating on the implant of this thickness. We determined to define a significant subsidence to be axial migration of more than 2 mm of either the proximal or distal implant when comparing the immediate postoperative radiographs to those taken at the final follow-up. Measurements were made from lateral radiographs, following the methods described by Sweets and Stern (2011). The distance was calculated from the implant articulating surface to the joint surface of the head of the middle phalanx and the base of the proximal phalanx, respectively.

We assessed dorsal, volar, rotational and/or coronal migration in anteroposterior or lateral radiographs) of each implant within the medullary canal. Mean patient age at the time of surgery was 61 years (range 52–68). Mean follow-up was 8.3 years (range 74–112 months). The minimum follow-up was 6.2 years.

A dorsal surgical approach as described by Chamay (1988) was performed, creating a distally based triangular flap of the dorsal apparatus. The prosthesis was inserted in press fit technique.

The joint was splinted in extension postoperatively. Except for those times of rehabilitation exercises the splint was worn for six weeks postoperatively. Two days after surgery active flexion to 30° of the joint was initiated. At the second week postoperatively active flexion was increased to 50° and finally at week six active flexion was increased to 80°. Three months postoperatively patients were allowed unrestricted grip activities if the radiographs taken at that time were unremarkable. Initial radiograph controls were done within 2–3 days postoperatively.

Results

The 13 implants documented in this report included four index fingers, three middle fingers, five ring fingers and one little finger. Of the ten patients represented in the report, all but one was satisfied with the treatment and would be willing to undergo the treatment again. Postoperative examinations documented five digits to be free of pain; the remaining digits had mild to moderate pain (VAS 2–5).

The average active ROM improved from 46° (SD 8°) preoperatively to 58 °(SD 19°) at time of follow-up examination. Two digits demonstrated a free active extension, in two digits a swan neck deformity was observed, which could actively not be overcome. The remaining fingers had an extension deficit of 5°–40°. Collateral ligaments were intact and stable at follow-up.

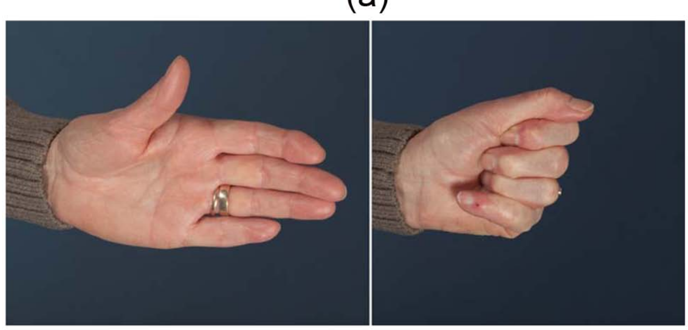
Radiograph examination was unremarkable, showing no signs of loosening or migration in six patients (Figure 1). In seven prostheses significant radiolucent lines (≥ 1 mm) were detected. Three prostheses demonstrated a migration of the proximal component (Figure 2), and one with an axial rotation (Figure 3). One patient presented with a subsidence of the distal component.

Two fingers required early revision surgery for stiffness. For both these cases the PIP joint was stiff in full extension. Intra-operatively the tendon was

(a) (b) (c)

Figure 1. (a) Pre-operative and postoperative x-rays of a 69-year-old patient. Postoperative x-rays taken two days after implantation (b) compared with the x-rays.after a follow up of 8.8 years (c). A periprosthetic lucency of 1 mm and more is not observed. In addition, a significant subsidence of more than 2 mm or a dorsal, volar, rotational and/or coronal migration of the prostheses is not noted.

(a)



(b)

Figure 2. A 64-year-old patient. Postoperative x-rays show a migration and rotation of the proximal implant 6.8 years after implantation of a pyrocarbon prosthesis for the PIP joint of the little finger (a). However, the clinical examination demonstrates a range of motion of 60° (b).

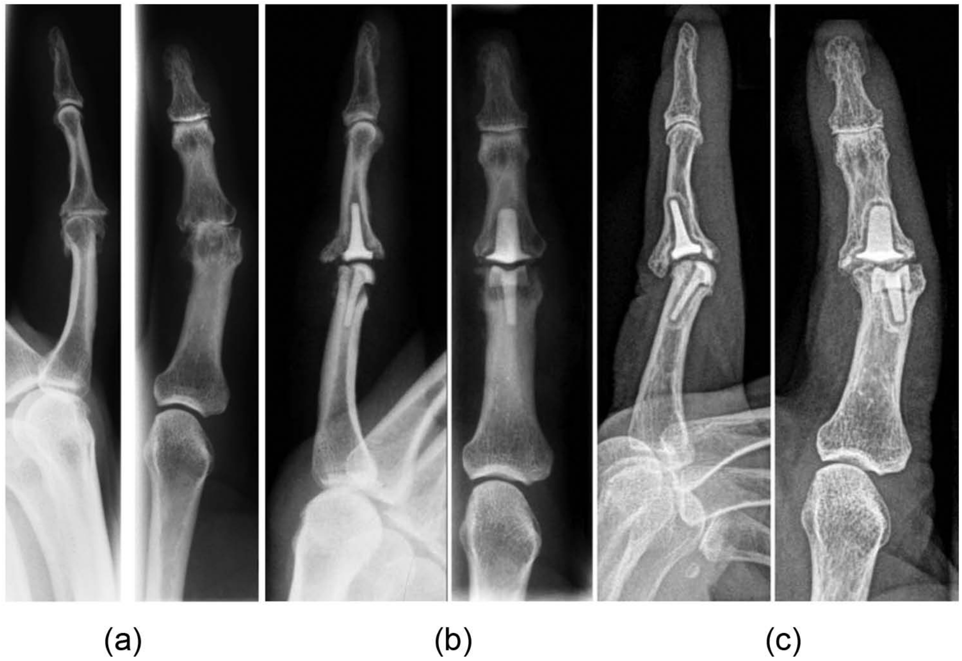


Figure 3. Pre-operative (a) and postoperative x-rays of a 64-year-old patient. Postoperative x-rays taken two days postoperatively (b) compared with the x-rays after a follow up of 8.5 years (c). At follow up a migration and rotation of the proximal and distal implant was observed.

observed to adhere to the bone and bone had formed within the joint capsule, which was removed. Postoperatively, active ROM improved by 10° for one finger, and 70° for the other. To date, from all 13 prostheses in our series no implant has been explanted, and no subluxation, implant fractures or infections have been observed.

Discussion

The goal of arthroplastic surgery is to improve function and decrease pain. Unconstrained prostheses reproduce the anatomy and would theoretically be the best choice for PIP joint replacement given that the capsule, ligaments and muscles provide joint stability (Fayaz et al., 2007; Uchiyama et al., 2000).

Early short-term evaluations had indicated promising outcomes for the PIP joint pyrocarbon implants (Cook et al., 1999; Heers et al., 2006; Meier et al., 2007; Schulz et al., 2005). Despite this, the lack of osteointegration between the pyrocarbon and host bone could be demonstrated (Daecke 2006), and was considered the reason for the high rate of periprosthetic radiolucencies observed. Clinical outcomes, however, did not correlate with the radiological findings in these early reports.

For our long-term series, we found radiolucent lines (≥ 1 mm), implant subsidence, implant migration and a loss of motion to be common complications. Migration rates of 21%–63% of the pyrocarbon implant have been reported, in addition to loosening rates leading to reoperations of 8%–14% (Hutt et al., 2012; Luther et al., 2010). Sweets and Stern (2011) noted a total of 60 complications in 31 prostheses, including one implant breakage, loosening rates of 48% and 5 (16%) dislocations. In addition, implant subsidence of more than 2 mm was observed in 12 (39%) of the 31 implants in the proximal phalanx and five (16%) of 31 implants of the middle phalanx.

In our series, implant subsidence and/or migration was observed in four cases (31%). Regardless of these findings, no dislocations of the joints were observed and no implant has been removed.

McGuire et al. (2012) observed implant subsidence in 40% of joints. Despite these observations, he reported no correlation between the subsidence and arc of motion or function.

Early investigations noted a ROM at final follow-up ranging from 50°–60° for pyrocarbon prostheses (Cook et al., 1999; Heers et al., 2006; Meier et al., 2007; Schulz et al., 2005). For our long-term series the average active ROM improved modestly from 46° (SD 8°) preoperatively to 58° (SD 19°) at time of last follow up. McGuire et al. (2012) found an increase in mean arc of motion of 36° after a minimum follow-up of one year.

Hutt et al. (2012) observed no statistically significant increase in postoperative active ROM after a mean of 6.2 years. Mashhadi et al. (2012) reported some modest improvement in the active ROM that was not statistically significance after a minimum follow-up of three years. Sweets and Stern (2011) noted a significant deterioration of the average ROM over time reducing to 31° at the final follow up examination.

In our series, two fingers required early revision surgery for stiffness. In both these cases the PIP joint was stiff in full extension. Intra-operatively the tendon was adhered to the bone and there was bone formation within the joint capsule, which was removed. The exact cause for the loss of motion seen postoperatively remains controversial. The dorsal approach according to Chamay has been discussed as a possible reason for the loss of motion owing to a dehiscense of the tendon suture, in addition, to scarring with subsequent tendon adhesions (Chamay, 1988; Herren and Simmen, 2000; Luther et al., 2010; Schneider, 1991).

Extensor mechanism dysfunction has been described by some authors as the most common cause of revision surgery (Hutt et al., 2012; Luther et al., 2010; McGuire et al., 2012; Sweets and Stern, 2011). In a study by Pritsch and Rizzo (2011) the authors describe a revision rate of 76 from 294 implants in a mixed series of patients suffering from degenerative and inflammatory arthritis, in which both pyrocarbon and metal–plastic implants were used. Most reoperations were owing to tendon adhesions. Therefore, a palmar approach has been advocated by some authors. However, significantly better results were not achieved (Duncan et al., 2009; Herren and Simmen, 2000; Schneider, 1991). The rehabilitation protocol may play a role. On the other hand, Sweets and Stern (2011) noted a significant deterioration of the average ROM over time from 51° at one year, reducing to 31° at the final follow-up examination. In addition, ROM varied from 0°–100°. These results appear difficult to be explained primarily by the rehabilitation protocol, as the decreases of the ROM can occur long after initial rehabilitation has ended.

An alternative to carbon, an unconstrained metal–plastic design (AVANTA SBi) is available for PIP joint replacement. The distal component has an articular surface of high density polyethylene fixed to a titanium base and stem, and the proximal component is a cast chromium–cobalt alloy with a polished articular surface and a shot blast stem.

Although this implant is provided with a porous coating, loosening has been reported (Luther et al., 2010; Pritsch and Rizzo, 2011). In addition, the number of reoperations has been shown to be significantly higher with metal–plastic than with pyrocarbon implants (Ampofo and Aerni, 2011; Pritsch and Rizzo, 2011).

Many studies noted high patient satisfaction and significant pain reduction (Heers et al., 2006; Meier et al., 2007; Schulz et al., 2005), which we did not observe in our series. However, owing to the retrospective design of all studies cited, including our own, a comparison of pre-operative and postoperative pain levels should always be made with caution.

Silicone interpositional arthroplasty is the current alternative PIP resurfacing arthroplasty utilizing metal–plastic and pyrocarbon implants for the finger. However, a report that compared pyrocarbon and silicone implants found no significant advantage between revision rates or ROM between the two designs (Branam et al., 2007).

The relatively small number of patients reported in this series is a possible weakness when concluding the effectiveness of the carbon PIP implants. However, the length of time in which these patients have had and utilized the implants is unique, and represents a longer-term history than many reports concerning the pyrocarbon design to date

Conclusion

Our study does not support the use of this implant for treatment of osteoarthritis of the finger joint owing to high complication rates and limited ROM.

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Conflict of interests

None declared.

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