

Pyrocarbon interposition arthroplasty for proximal capitate avascular necrosis

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Abstract

Introduction Avascular necrosis of the capitate head is a rare condition commonly treated with partial wrist fusion. Although good functional results are usually reported, a degree of stiffness is to be expected. We report a pyrocarbon interposition arthroplasty technique in a young sportsman with 3.5 years of follow-up.

Methods A 15-year-old rugby player presented with a 6-month history of wrist pain and stiffness with no preceding injury. The necrotic bone was replaced with interposition of a pyrocarbon interposition implant (PI²) (Tournier, Grenoble, France), originally designed to replace the trapezium. A concave socket was created in the distal fragment to accommodate the implant and prevent dislocation. Regular follow-up included subjective and objective measures.

Results He was pain free by 6 weeks and regained good functional range of motion and grip strength by 3 months. He returned to playing rugby at the 1-year follow-up. At 2 years, he remained asymptomatic. After 3.5 years, he had no limitations in his heavy manual work as a plant mechanic and retained a good functional range of motion including the dart-thrower's motion.

Conclusions Medium-term results appear to offer the benefits of being able to return to heavy manual labour as well as retaining a functional range of motion. It is difficult to predict long-term survival, but the outcome so far is encouraging, and conversion to midcarpal fusion remains a salvage option.

Keywords Avascular necrosis · Capitate · Interposition arthroplasty · Pyrocarbon · Wrist

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Introduction

Avascular necrosis (AVN) of the capitate head is a rare condition that is usually secondary to trauma or systemic insults such as steroid use. Idiopathic capitate AVN has also been reported where there has been no history of direct or indirect trauma and no history of steroid use or systemic illness [6, 8]. There are numerous case reports in the literature with suggestions for management, although most refer to some form of partial wrist fusion [2, 3, 5, 7, 11]. Although good functional results are usually reported, a degree of stiffness is to be expected. We report a pyrocarbon interposition arthroplasty technique in a young sportsman with 3.5 years of follow-up.

Case Report

A 15-year-old schoolboy presented with a 6-month history of progressively worsening pain and stiffness in his left, non-dominant wrist. Although a rugby player, he could not recollect a specific injury. Examination revealed mild fullness on the dorsum of the wrist that appeared to be originating from the joint rather than the extensor tendons with minimal associated tenderness. Passive and active ranges of motion were significantly restricted; in particular, passive extension was limited to 40°.

Radiographs showed a faint radiolucent area on the dorsoradial aspect of the capitate head with an irregular outline. Computed tomography demonstrated bone fragmentation consistent with avascular necrosis (Fig. 1). In view of his young age and athletic aspirations, we were reluctant to offer partial wrist fusion. Instead, we elected to replace the necrotic capitate head with a pyrocarbon spacer as a temporary measure to relieve pain and preserve motion. The possibility of having to revert to partial fusion in case of future failure was discussed preoperatively.



Fig. 1 Initial computed tomography scan demonstrating AVN of the capitate head

Access to the midcarpal joint was obtained through a dorsal ligament sparing approach as described by Berger et al. [1]. The proximal pole of the capitate was found to be very soft and necrotic at operation. It was burred back to healthy bleeding cancellous bone and fashioned into a socket by creating a cancellous concavity (Fig. 2). The proximal articular socket formed by the lunate and scaphoid was retained despite moderate chondromalacia being present on the midcarpal joint surfaces of the lunate and scaphoid. A medium size, biconvex pyrocarbon interposition implant (PI²) (Tournier, Grenoble, France) was then inserted into the newly fashioned biconcave socket after trialling for size (Fig. 3). This implant was originally designed to replace the trapezium for first carpometacarpal joint osteoarthritis so this was an ‘off-label’ use. Intraoperative fluoroscopy demonstrated stability of the implant throughout the range of motion with no impingement.

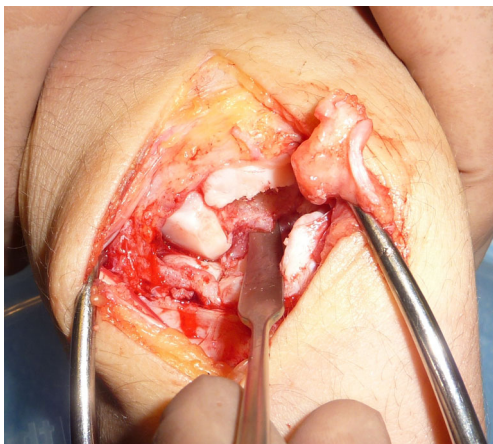


Fig. 2 Intraoperative photograph demonstrating the concave socket burred into the proximal capitate



Fig. 3 An intraoperative photograph demonstrating the PI² implant within its new bony socket

His wrist was immobilized with a dorsal plaster splint then converted to a removable splint after 12 days. Gentle active wrist mobilisation was commenced with hand therapists. By 6 weeks, the patient was pain free and he had achieved 40° each of wrist extension and flexion. Passive mobilisation exercises were commenced, but he was advised against loading the wrist for another 6 weeks.

Results

At 3 months, he remained pain free with 45° of extension and 50° of flexion. He was encouraged to return to all normal activities, apart from rugby. By 1 year, he had returned to rugby without problems. At his most recent follow-up at 3.5 years postoperatively, he had been working full time as a construction plant mechanic for 2 years including heavy lifting and use of manual and power tools. He continued to play rugby with strapping on his wrist with no difficulties but occasional pain on impact. He also worked on a farm in his spare time and enjoyed shooting.

His Disabilities of Arm, Shoulder and Hand (DASH) score was 0.8/100 at 1 year, 1.7/100 at 2 years and 3.3/100 at 3.5 years (where 0=no disability and 100=maximum disability). He scored an extra point at 2 years for an occasional mild ache in the wrist following a heavy day at work. At 3.5 years, his extra score was for reporting moderate difficulty performing recreational activities involving force or impact through the wrist. Although no preoperative DASH score was recorded, the patient reports marked improvement in symptoms and function postoperatively. The ache was scored 2/10 at worst following a heavy day’s use and resolved spontaneously each evening. His ability to carry out his work duties or hobbies was not affected, and he reported no symptoms of instability or catching.

Table 1 Postoperative passive wrist ranges of motion (in degrees measured with a goniometer) and grip strength (best from three measurements with a Jamar 2 dynamometer)

Movement	1 year		2 years		3.5 years	
	Right	Left	Right	Left	Right	Left
Flexion/extension	85/65	55/45	85/65	45/45	85/75	60/50
Ulna/radial deviation	25/20	25/15	40/30	30/15	35/25	45/15
Pronation/supination	90/90	90/90	90/90	90/90	90/90	90/90
Grip strength (kg)	50	42	44	36	47	47

Wrist ranges of motion throughout follow-up are recorded in Table 1. Flexion and extension were slightly limited compared to his normal wrist. Dart-thrower's (midcarpal) range of flexion/extension at 3.5 years was 28/32° on the left and 40/38° on the right. Grip strength remained comparable to his normal, dominant wrist (Table 1). Radiographs at each follow-up appointment confirmed a well-seated prosthesis with no evidence of osteolysis, but possibly some mild sclerosis in the distal lunate and proximal capitate (Fig. 4). Using the implant as a sizing template for the radiographs, carpal height was comparable measuring 33 mm at 6 weeks postoperatively and 32.5 mm at 3 years postoperatively.

Discussion

Similar to the scaphoid, the capitate has a poor blood supply, usually from a solitary distal dorsal nutrient vessel that enters

the bone through a non-articular surface and supplies the bone in a retrograde fashion. Even when there are both palmar and dorsal nutrient vessels entering the capitate, there are rarely any intraosseous anastomoses present. This renders the proximal pole highly susceptible to AVN following injury or other insults [9]. Unlike other carpal bones, the capitate is not as commonly injured due to its relatively protected location in the centre of the distal row of the carpus and higher-energy trauma is usually required [4].

Most authors report poor results with conservative management compared with operative management [10]. Although initial splinting may help with early pain relief, capitate length should be preserved or restored to prevent wrist collapse and arthrosis. If carpal height cannot be restored, then patients can be treated with limited intercarpal fusion (capitolunate, capitolunate, scapholunocapitate or four-corner arthrodesis) [6, 8, 10, 11]. This approach reliably addresses pain but inevitably leads to loss of motion and puts extra stress through neighbouring joints. Partial denervation of the wrist by anterior and posterior interosseous neurectomy may help control pain but will not prevent collapse of the wrist and arthrosis if used in isolation.

Methods previously used to retain capitate length following AVN include excision of the necrotic bone and, where there is an intact proximal capitate, interposition of a vascularized bone graft [3, 8].

In late cases with more extensive AVN and associated carpal collapse, tendon graft interposition has been described with variable results [5, 7]. Kimmel and O'Brien used a palmaris longus anchovy graft reporting only mild pain and

Fig. 4 Anteroposterior (a) and lateral (b) radiographs at 3 years postoperatively showing no change other than normal physseal closure



recovery of preoperative range of motion at 10 months [5]. Lapinsky and Mack tried to replicate these results using the fourth toe extensor tendon but immobilized the patient for 6 weeks postoperatively in a long-arm cast. The patient still had significant pain at 6 months so a wrist arthrodesis was performed. Only one previous author from the English literature reported the use of a synthetic prosthesis. In this case, a silicone elastomer universal small joint spacer was used. The patient returned to work as a lorry driver and mechanic with only mild aching in the wrist at 2 years [2]. There is already a pyrocarbon implant designed specifically for resurfacing the proximal capitate following proximal row carpectomy to allow articulation with the distal radius (Resurfacing Capitate Pyrocarbon Implant (RCPI®); Tournier, Grenoble, France). This implant is much larger than the PI² with a large central peg which necessitates greater soft tissue dissection if the proximal row is preserved such as in this case.

Most treatments reported for capitate AVN demonstrate reasonable short-term results. None, including this report, provide information on long-term outcomes, so there remains a lack of consensus on the best treatment. Compared to partial carpal fusion, we believe that this interposition arthroplasty technique is more likely to maintain capitate height, preserve wrist mechanics, afford a better range of motion (in particular the midcarpal dart-thrower's motion) and avoid arthrosis in neighbouring joints. It also restored grip strength to normal. Early mobilisation can commence soon after the surgery as there is no graft or arthrodesis site to protect. Pyrocarbon has a similar modulus of elasticity to bone and is less compressible than tendon grafts and silicone implants. This material has been successfully used in the hand and wrist for replacement of arthritic joints and necrotic scaphoids, partly due to the lower loading forces at play compared to the lower limbs.

The PI² was originally designed to replace the excised trapezium bone in thumb basal joint osteoarthritis. Dislocation of the implant is a potential complication. We attempted to limit this by creating a bony socket for the implant, using a ligament splitting approach and limiting loading exercises postoperatively. However, being over-cautious with physiotherapy in this instance may have contributed to his residual stiffness.

This new technique has afforded relief of pain and return to heavy manual labour and impact sports. We acknowledge the limitation of the study's short-term results. Pyrocarbon interposition arthroplasty may lead to sclerosis and cystic changes within the capitate and lunate in the long term. However, we

feel that this treatment does not burn any bridges as any future failure could still potentially be managed with limited carpal fusion and grafting. Although this is only a single case report for which we await long-term follow-up, this technique demonstrates promising potential and is worth consideration as a valid treatment option for proximal pole capitate AVN.

Conflict of Interest Nikolas A. Jagodzinski declares that he has no conflict of interest.

Clare F. Taylor declares that she has no conflict of interest.

Anmar K. Al-Shawi declares that she has no conflict of interest.

Statement of Human and Animal Rights No human or animal rights have been infringed.

Statement of Informed Consent Informed consent was gained from the patient.

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