CASE REPORT

Long-Term Outcomes of Pyrocarbon Hemiarthroplasty in a Young Patient with Severe Chondrolysis

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Abstract

Pyrocarbon hemiarthroplasty is a novel procedure that has shown promise for the complex cases of young patients with severe shoulder arthritis. This prosthesis aims to overcome challenges faced by conventional hemiarthroplasty designs, particularly the issue of significant glenoid arthrosis over time. Results of the pyrocarbon hemiarthroplasty have generally shown good promise, but there has been a scarcity in studies and reports that explore the long-term outcomes of this procedure. In this report, we describe the case of a young male patient who underwent a pyrocarbon hemiarthroplasty for significant glenohumeral chondrolysis. The patient underwent the procedure and was able to demonstrate seven-year postoperative outcomes, reporting an American Shoulder and Elbow Surgeon's score of 97, a single assessment numeric evaluation score of 95 and a visual analogue scale pain score of 0 at final follow-up. Radiological imaging revealed some progressive glenoid arthrosis and superior glenoid erosion over the course of seven years.

Level of evidence: V

Keywords: Arthrosis, Glenoid, Partial replacement, Pyrolytic carbon, Resurfacing

Introduction

One of the apparent trends in shoulder surgery over the recent decades is the rise in the popularity and incidence of total shoulder arthroplasty (TSA) procedures, due to the expansion of its indications, encouraging patient outcomes, and innovative technological advancements and surgical designs.[1-5] That being said, this rise was coupled with a decline in the popularity of the hemiarthroplasty procedure, evident by a decrease in its incidence over the years.[1,2] While TSA replaced the need for shoulder hemiarthroplasty in many cases, the procedure remains one of utility in the repertoire of shoulder surgeons, especially in young patients suffering from osteoarthritis or avascular necrosis, among other etiologies.[1,6-8] Advantages of this procedure mainly lie in it preserving glenoid bone stock, avoiding the use of polyethylene with its inherent drawbacks, and requiring a shorter surgical time to complete.[1,6-8]

While advantages of shoulder hemiarthroplasty remain prominent, several disadvantages and potential complications can lead to poor outcomes and the need for revision surgery, especially glenoid arthrosis.[9-13] Glenoid arthrosis, and its associated potentiation of pain, remain a significant complication following hemiarthroplasty that deters surgeons from selecting it as the surgical option of choice when deciding on the management plan.[10] This is due to the articulation of the metal humeral head with the native glenoid, and can subsequently lead to bone erosion, pain and joint line medialization.[10] While many studies explored the use of different techniques and methods to try and minimize glenoid arthrosis following hemiarthroplasty, reported outcomes were mostly equivocal.[13,14]

Recently, an alternative bearing surface, in the form of pyrolytic carbon (pyrocarbon), was introduced to shoulder hemiarthroplasty procedures in an attempt to decrease glenoid arthrosis following the procedure.[15-17] This material showed promising results in early in-vitro studies, which reported reduced wear rates compared to other materials.[18,19] Clinical studies have reported promising

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short-term outcomes following pyrocarbon shoulder hemiarthroplasty.[15,16] Given the relative novelty of this technology, studies exploring the mid-term and long-term outcomes remain scarce. As such, it is of pivotal importance to report on cases with long term outcomes that have utilized this technology. In this report, we present the case of 29-year-old male patient who presented to our clinic with severe chondrolysis due to an intra-articular pain catheter used for postoperative pain control after a previous shoulder stabilization procedure. The patient was treated with a pyrocarbon hemiarthroplasty and has shown promising results at 7 year follow up. (The patient provided consent for their deidentified clinical and radiographic data to be published in this report.)

Case Presentation

A 29-year-old right-hand dominant male IT technician presented for evaluation of his right shoulder pain. The patient's history dates back to six years prior when he underwent an arthroscopic procedure in the right shoulder for a labral repair related to shoulder instability. Following the procedure, the patient had an intra-articular pain pump implanted for post-operative pain control. Approximately one year following his surgery, the patient experienced persistent pain in his shoulder that eventually led to stiffness and loss of function. He returned to his operative surgeon who indicated that he had developed chondrolysis due to the intra-articular pain pump used postoperatively Subsequently, his chondrolysis was managed conservatively with multiple cortisone injections. Yet, over time, the injections yielded diminishing returns in alleviating his pain and he had significant progression of stiffness in his shoulder. The patient reported difficulty with sleeping and any overhead activities, as well as diminished ability in performing activities he used to enjoy, such as weightlifting, due to pain and dysfunction. He did not take any pain medications, though he was using Voltaren gel, which provided him with some moderate relief. He was a non-smoker, with a BMI of 25.09 (height 6ft, weight 185lbs), and has no pertinent medical history.

On physical examination, his range of motion was limited, reaching only 70 degrees in active forward elevation, 30 degrees in active abduction, and 5 degrees in active external rotation with arm at side. On his contralateral side, he was able to reach 160 degrees in forward elevation, 110 degrees in abduction, and 65 degrees in external rotation. He had no apprehension or signs of instability, and was neurovascularly intact distally. His American Shoulder and Elbow Surgeons (ASES) score was 30.00, his Visual Analogue Scale (VAS) pain score was 8/10, his Single Assessment Numeric Evaluation (SANE) score was 30%, and Simple Shoulder Test (SST) was 66.67. X-ray imaging revealed severe end-stage glenohumeral arthrosis with complete loss of articular cartilage, osteophyte formation and early posterior subluxation of the humeral head on the glenoid [Figure 1].

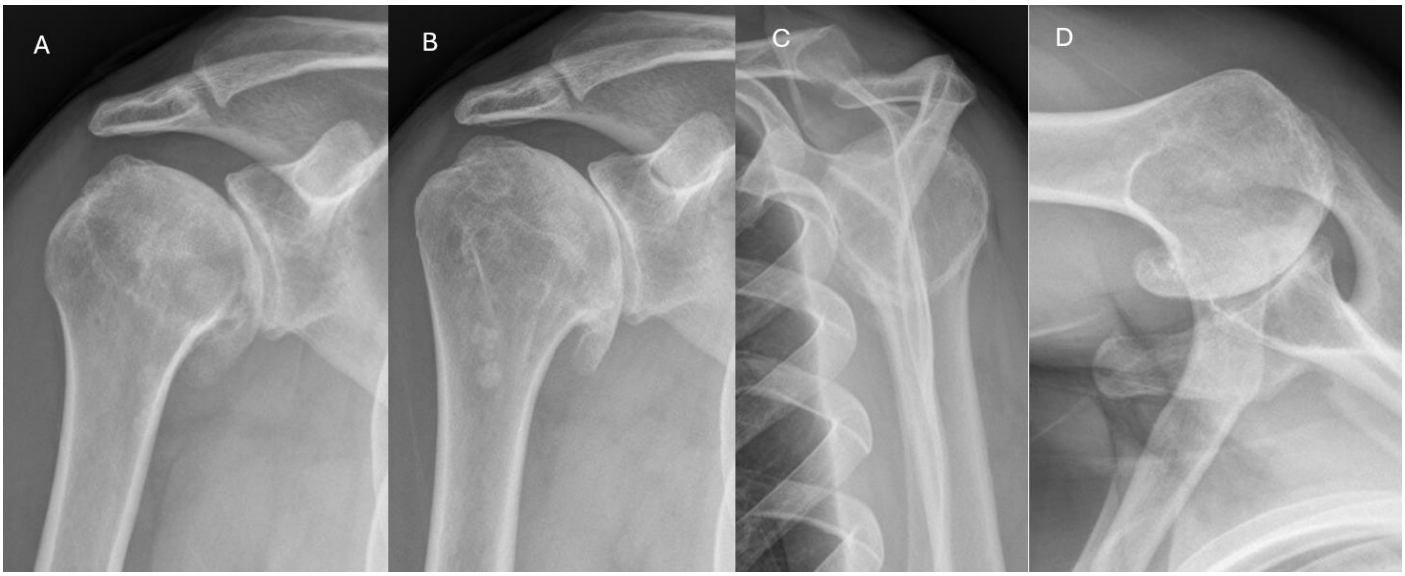

Figure 1. X-ray imaging of the patient at presentation showing severe end-stage glenohumeral chondrolysis and osteoarthritis according to anteroposterior views (A and B), scapular Y view (C), and axillary view (D)

The patient was informed about his diagnosis and possible management options. As the nature of his arthritis would not be amenable to any arthroscopic surgery, his options included continued conservative management, hemiarthroplasty, and total shoulder arthroplasty. Given his severe arthritis and young age, the treatment plan was decided on performing a pyrocarbon hemiarthroplasty, as part of the Investigational Device Exemption trial being conducted in 2016. During the procedure, all humeral osteophytes were excised, the humeral head was osteotomized in approximately 30 degrees of retroversion, the glenoid was exposed, and a capsulotomy was performed in a standard fashion. In addition, degenerative labral tissue was excised as deemed appropriate. The glenoid surface was not reamed; however, we did perform unicortical drilling of the glenoid face on multiple sites to vent the bone. The

humeral shaft was prepped and sized to receive the appropriate stem. The humeral head was trialed, and the appropriate head size was found to be 48 x 18 pyrocarbon implant. On exposure, the subscapularis was peeled, and on closure, it was repaired in a transosseous fashion. Immediate postoperative X-rays were performed [Figure 2]. The procedure was well tolerated, and the patient was placed in a sling for 10 days up until his first postoperative visit. Afterwards, the sling was removed and the patient was instructed to start physical therapy.

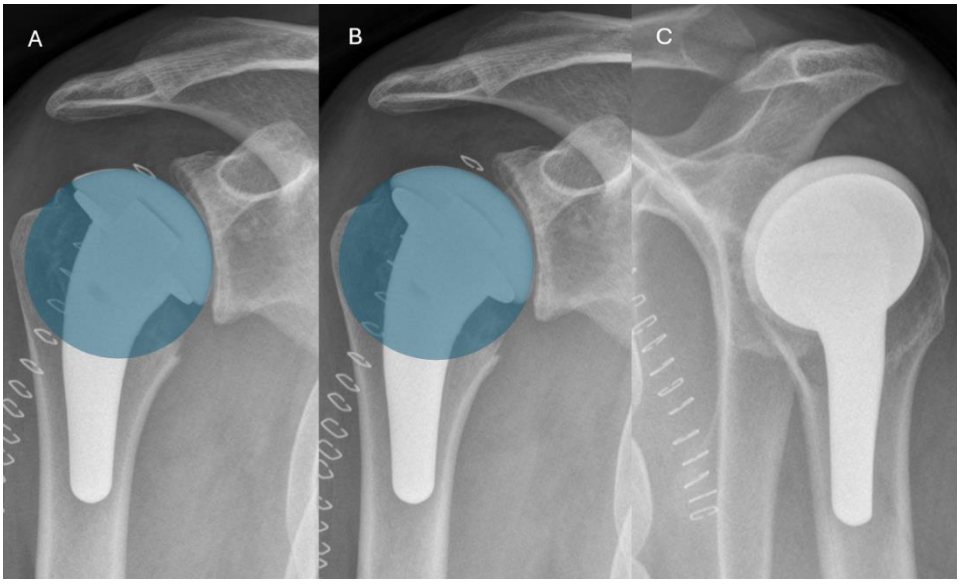

Figure 2. Immediate postoperative X-ray performed following pyrocarbon hemiarthroplasty according to anteroposterior views (A and B), and scapular Y view (C). Blue circle demonstrates slight overstuffing of the joint, but otherwise good positioning of humeral components

The patient did well with his postoperative recovery. At 6-weeks postop, the patient reported having increased function and reduced pain by 80%-90%, and demonstrated active forward elevation to 130 degrees, active abduction to 80 degrees, active external rotation with arm at side to 45 degrees, and active internal rotation to the L1 level. He continued to progress with his recovery, reaching 160 degrees in active forward elevation, 100 degrees in active abduction, 45 degrees in active external rotation with arm at side, and 85 degrees in active external rotation with arm abducted to 90 degrees, at the 5-months mark. At 1-year postop, the patient demonstrated full active range of motion and excellent strength overall, with forward elevation to 175 degrees, abduction to 90 degrees, external rotation with arm at side to 70 degrees, external rotation with arm abducted to 90 degrees to 70 degrees, and active internal rotation to the T10 level. His VAS score was 1/10, ASES score was 86.67, SANE score was 85%, and SST score was 91.67. His X-rays showed the humeral components to be slightly overstuffed, but otherwise in good position with no evidence of any component migration or loosening [Figure 3].

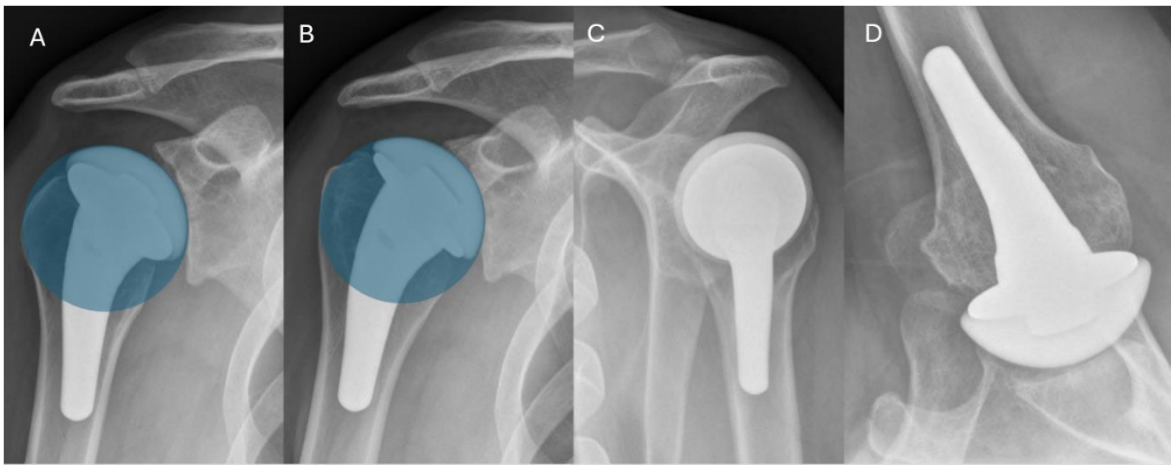

Figure 3. X-ray imaging at 1-year after surgery according to anteroposterior views (A and B), scapular Y view (C), and axillary view (D). Blue circle demonstrates slight overstuffing of the joint with components to be in excellent position

Subsequently, the patient returned annually for routine follow-up with X-ray imaging until his most recent follow-up of 7-years. At his latest follow-up visit at 7-years and 5-months postop, the patient was very satisfied with his outcome, continued to work in IT with the feeling of having a fully functional shoulder, and denied any pain, tingling, numbness, or other complaints. On examination, he demonstrated bilaterally 170 degrees of forward flexion, 170 degrees of abduction, 45 degrees of external rotation with arm at side, and internal rotation to the T10 level [Figure 4]. His VAS score was 0/10, ASES score was 97, and SANE score was 90%. X-rays showed components to be in appropriate position without any evidence of loosening, migration, or fracture [Figure 5]. Sequential X-rays in AP view at 1-year intervals from the first to last postoperative visit are presented in [Figure 6]. It can be seen that progressive mild superior glenoid erosion occurred, particularly during the first four years, before stabilizing over the next three years [Figure 6].

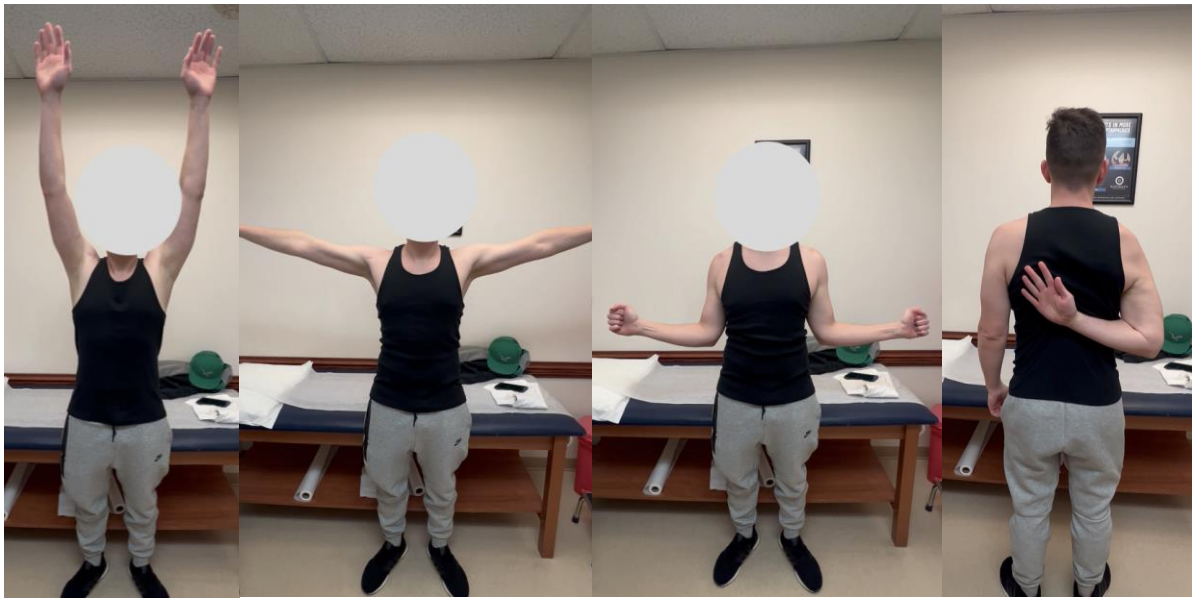

Figure 4. Excellent range of motion demonstrated at 7-years postop: Forward elevation (a), Abduction (b), External rotation (c), and Internal rotation (d)

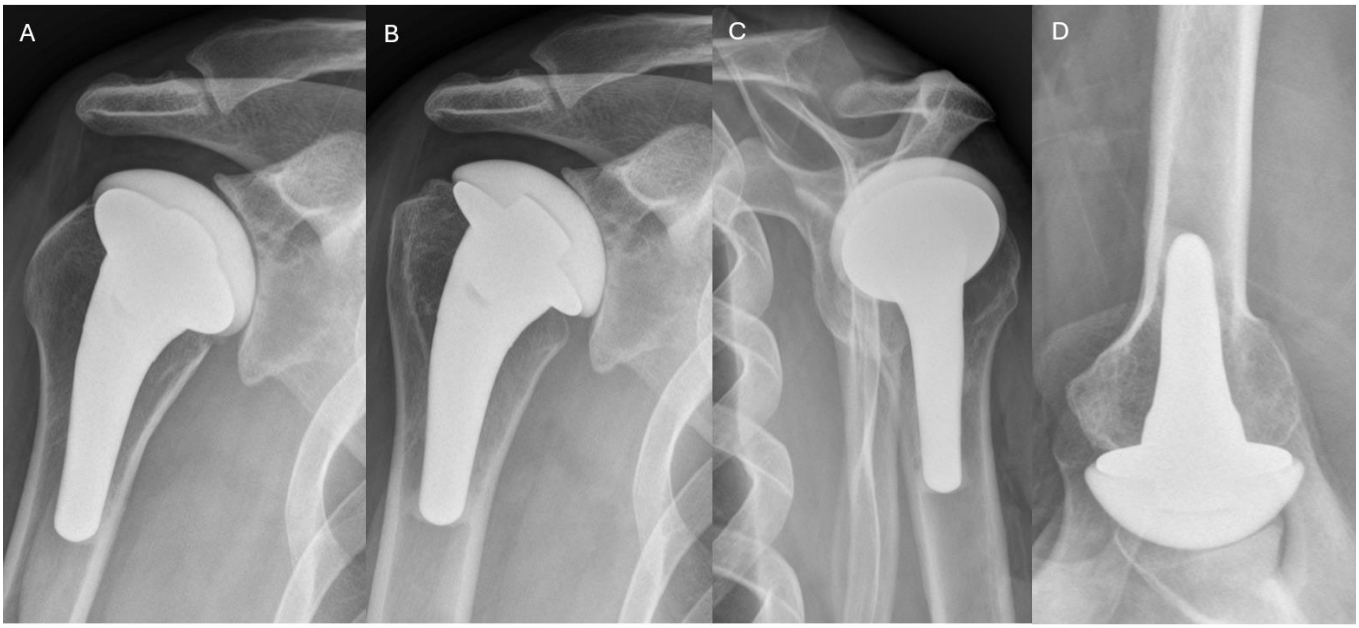

Figure 5. X-ray imaging at 7-years after surgery showing components to be in appropriate position according to anteroposterior views (A and B), scapular Y view (C), and axillary view (D)

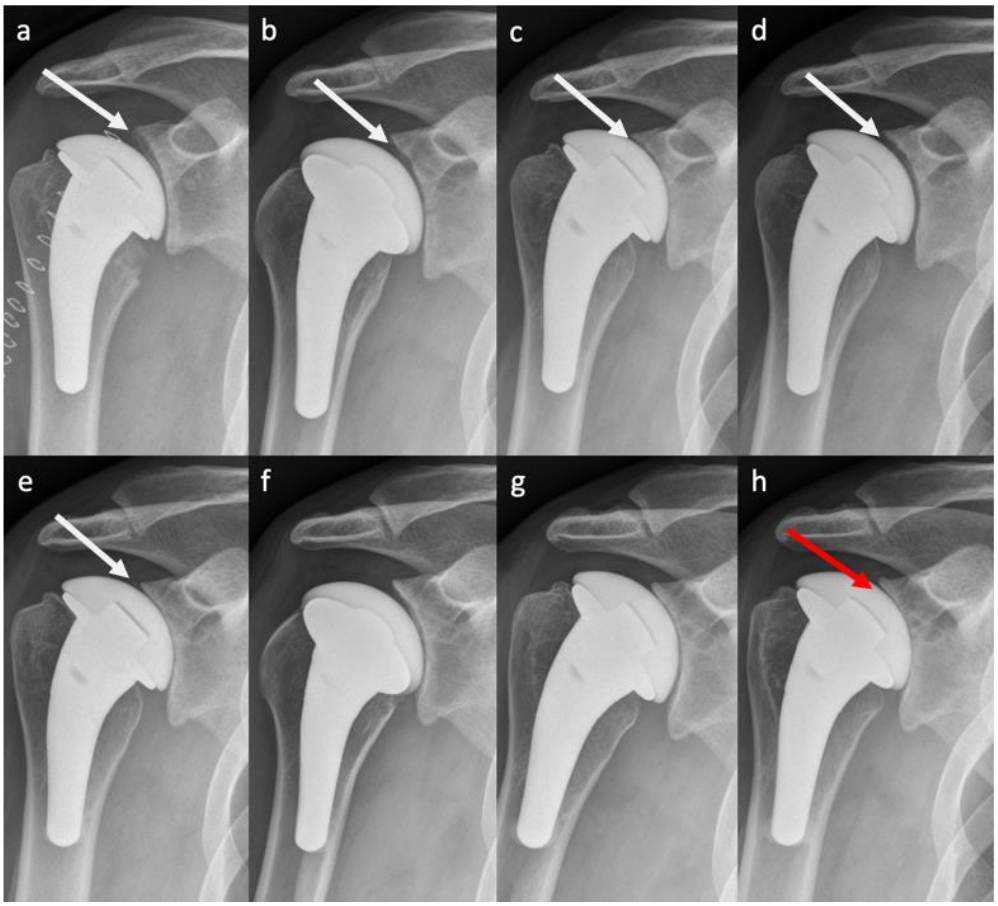

Figure 6. Sequential X-rays in AP view at 1-year intervals: 1st Postop (a), 1-Year (b), 2-Years (c), 3-Years (d), 4-Years (e), 5-Years (f), 6-Years (g), and 7-Years post-op (h). Mild superior glenoid erosion can be seen over the first four years postoperatively (a-e; white arrows), before stabilizing in later years (h; red arrow)

Discussion

Our report shows that pyrocarbon hemiarthroplasty can serve as an effective therapeutic option for a young patient affected by arthritis secondary to post-capsulorrhaphy arthropathy and chondrolysis, with favorable long-term results that can be seen years after the index procedure. The pyrocarbon hemiarthroplasty may revitalize the use of shoulder hemiarthroplasty, which has seen a decline in popularity over the years.[17] It may also offer a solution to the challenging clinical cases of young patients with minimal centric glenoid wear and significant humeral-sided arthritis and cartilage loss; for whom conservative treatment has been ineffective, and the avoidance of total shoulder replacement has been desired.[17]

The benefits entailed by pyrocarbon hemiarthroplasty mainly lie in the composition and properties of pyrolytic carbon, which has been known to be a strong, durable and wear resistant coating with numerous medical applications.[17-20] previous in vitro and animal studies have shown pyrocarbon to have better wear characteristics, biocompatibility, and a less corrosive relationship with bone and cartilage than when compared to alternative materials used in prostheses, such as chromium cobalt.[21,22] These properties suggest a reduction in glenoid wear with the use of pyrocarbon hemiarthroplasty, thereby addressing a longstanding problem inherent to the conventional shoulder hemiarthroplasty.[17,21,22] was seen by our patient, whose x-rays showed mild glenoid wear during the first few postoperative years and then stabilization of the wear process in subsequent follow-up.

The use of pyrocarbon in the setting of shoulder hemiarthroplasty has recently garnered attention and generated interest among clinicians and surgeons alike, leading to its approval by the U.S. Food and Drug Administration (FDA) in 2022.[17,23] Several studies explored the use of the pyrocarbon hemiarthroplasty for young patients with osteoarthritis with generally positive outcomes.[24,25] One study by McBride utilized a national registry for joint replacement to explore the outcomes of young patients who underwent primary hemiarthroplasty for shoulder osteoarthritis.[24] In specific, the authors compared three cohorts of patients: those who underwent metal stemmed hemiarthroplasty (n=67), those who underwent metal humeral resurfacing (n=163), and those

who underwent pyrocarbon humeral resurfacing hemiarthroplasty (n=163).[24] At a mean follow up of 6 years, pyrocarbon had the lowest revision rate of 8.9%, compared to 17% for metal humeral resurfacing, and 17.5% for metal stemmed hemiarthroplasty.[24] The authors also noted that no pyrocarbon case was revised for glenoid erosion, thereby confirming the advantages of its inherent properties.[24] Another study by Hudek et al explored the use of pyrocarbon-coated interposition arthroplasty in patients with avascular necrosis of the humeral head, and noted significant improvements in clinical outcome scores at 3.6 years of follow-up.[25] The authors noted that the observed improvements were comparable those seen in patients undergoing anatomic TSA.[25]

While these studies seem encouraging, some results have emerged expressing concerns regarding the longevity of pyrocarbon hemiarthroplasty and its outcomes in certain clinical settings.[17] One study by Hirakawa et al, reported on a small population of 10 patients younger than 60 years old who underwent pyrocarbon hemiarthroplasty for a multitude of indications (osteoarthritis with Walch type B glenoids, avascular necrosis of humeral head, or severe secondary osteoarthritis).[26] At 5 year follow-up, five of the patients required revision to reverse TSA, while the remaining five had great outcomes.[26] A report by Dupley and Monga described catastrophic failure of a pyrocarbon hemiarthroplasty in a patient who had a residual metal anchors in the glenoid, at one year follow-up.[27] The anchors were from a previous open Bankart repair 20 years prior to the procedure, and led to mechanical abrasion with the pyrocarbon prosthesis.[27] Moreover, a study from Lyon explored the outcomes of pyrocarbon hemiarthroplasty in patients with different patterns of glenoid erosion.[28] Authors showed that patients with post-traumatic sequalae had lower levels of functional and pain improvements when compared to patients with primary osteoarthritis or osteoarthritis secondary to instability, showcasing how indications can affect outcomes in the setting of pyrocarbon hemiarthroplasty.[28]

Given the novelty of this procedure, studies and reports describing its long-term outcomes have been minimal, rendering the confirmation of its therapeutic efficacy equivocal. As such, our report offers a valuable addition to the literature, as it provides insight into the longevity and therapeutic potential of pyrocarbon hemiarthroplasty of the shoulder. In our case, our patient showed great outcomes seven years following his procedure, with an ASES score of 97, a VAS pain score of 0, a SANE score of 95 and mild glenoid arthrosis overall on x-ray, entailing promising results that can last for several years. To our knowledge, this report provides the longest follow-up after pyrocarbon hemiarthroplasty to date.

Conclusion

Pyrocarbon hemiarthroplasty is a promising procedure that can provide a solution for the challenging problem of young patients with glenohumeral osteoarthritis. By employing a pyrolytic carbon humeral head, this prosthesis is said to decrease glenoid arthrosis over time, increase biocompatibility, and decrease caustic interactions with cartilage and bone. While short and midterm results have shown good promise, little insight is known about the long term outcomes of this procedure. Our report describes the case of young patient with severe cartilage loss and osteoarthritis who underwent pyrocarbon hemiarthroplasty, and who retained benefits seven years after the procedure. It was observed that mild glenoid arthrosis developed in the first few years following the procedure, but then subsided over the remaining years. Our report provides valuable insight into the longevity and therapeutic potential of this promising novel procedure.

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