

Pyrocarbon Shoulder Hemiarthroplasty

What is it

A pyrocarbon hemiarthroplasty is a half shoulder replacement for [shoulder arthritis](#). The worn ball at the top of the arm bone is replaced with a smooth ball made of pyrocarbon, a very hard form of carbon, on a stem that sits inside the arm bone. Unlike a [total shoulder replacement](#), the socket (the glenoid) is left in place, and the new ball moves against your own socket.

It is mainly considered for younger, active people with arthritis, in whom a plastic socket might wear out or loosen during their lifetime. It is a newer option: the first results were published within the last ten years, and the longest follow-up so far is about ten years.

Why pyrocarbon

Half replacements have been used for many years with metal balls made of cobalt-chrome. Their main problem is that the hard metal gradually wears away the socket, which can become painful and lead to further surgery [1]. Pyrocarbon is very smooth and much less stiff than metal, with a stiffness close to that of bone. The idea is that it is gentler on the socket, so the socket wears less and the shoulder lasts longer [2].

Who it may suit

The best results have been reported in people whose socket is worn evenly, whose rotator cuff tendons are healthy, and whose arthritis followed earlier dislocations, or followed collapse of the ball from loss of its blood supply (avascular necrosis) [3][4]. Results have been poorer when the socket is badly worn at the back, when the tendon at the front of the shoulder (the subscapularis) is torn or weak, and when the new ball is larger than the patient's own [3][4].

A pyrocarbon half replacement is not suitable when the rotator cuff is badly torn; a [reverse shoulder replacement](#) is usually used instead.

What the results show

Compared with a metal half replacement, pyrocarbon has done better in every published comparison. In the Australian joint registry, about 9% of pyrocarbon implants in people under 55 had needed further surgery by 6 years, against about 17% of metal half replacements [1].

On its own, the larger studies report that 94–97% of shoulders have not needed further surgery at 5 years, and about 89% at 10 years in the longest series [4][5]. Most patients have less pain and better movement, and many return to work and sport [4].

Compared with a total shoulder replacement, the rate of further surgery so far looks similar [6][7]. In two studies, people who had a total shoulder replacement had slightly better early function or slightly less pain, although most patients in both groups did well [7][8].

Downsides and risks

The general risks are those of any shoulder replacement, described on the [total shoulder replacement](#) page. The risks particular to a pyrocarbon half replacement are:

- **The socket can still wear.** Pyrocarbon reduces socket wear but does not prevent it. Some wear has been seen on X-ray in roughly a quarter to a half of shoulders within several years, and when it progresses it is the main cause of pain and further surgery [9][4].
- **Pain that does not settle fully.** Some people are left with ongoing aching without a clear cause. In one large study, about 1 in 6 shoulders had not improved as much as expected at 2 years, although few of them had needed further surgery [10].
- **The size has to be right.** If the new ball is even slightly too large, the socket wears faster and further surgery becomes much more likely [4].
- **Breakage.** Pyrocarbon is hard but brittle. Fracture of the implant is uncommon but has been reported, mainly with the resurfacing cap version [6].

If further surgery is needed, the stem can usually be left in place and the shoulder converted to a total or reverse shoulder replacement, because the socket has not been replaced [4].

How certain is the evidence

The results so far are encouraging but limited. There are no randomised trials, most studies follow patients for less than 6 years, and many come from the surgeons who helped develop the implants [11]. Most studies measure success by whether further surgery was needed, which can miss shoulders that remain painful but are not operated on again [10]. Longer-term results, and results from a wider range of hospitals, are still to come.

Questions you may want to ask

- How worn is my socket, and is the wear even or mainly at the back?
- Are my rotator cuff tendons healthy?
- How would a half replacement compare with a total shoulder replacement for me?
- What would happen if the socket wore down in future?

In more depth

This section sets out the evidence in more detail, with the numbers from each study. Pyrocarbon hemiarthroplasty is a newer option, and the published results are worth reading closely: they are encouraging in some respects and disappointing in others, and the answer depends on what it is compared with.

WHY PYROCARBON WAS INTRODUCED

A hemiarthroplasty (half replacement) replaces the ball of the shoulder and leaves the socket (glenoid) alone. That avoids the main long-term problem of a total shoulder replacement in younger, active people, which is loosening and wear of the plastic socket. With a traditional cobalt-chrome metal ball, however, the native socket tends to wear away over time, often painfully. Erosion of the socket has been reported in 28–43% of shoulders with metal heads [1]. In the Australian joint registry, metal half replacements in people under 55 reached revision rates of about 17% by 6 years, largely because of socket wear and pain [2].

Pyrolytic carbon (pyrocarbon) is a very hard, very smooth form of carbon, made by depositing carbon from a gas onto a graphite core at high temperature. It is much less stiff than cobalt-chrome, with an elastic modulus close to that of bone, and it causes little friction against cartilage. It has been used for decades in heart valves and in small-joint replacements in the hand and elbow [3]. In the laboratory, cartilage cells grown on pyrocarbon produced more of the type of collagen found in healthy joint cartilage than cells grown on cobalt-chrome [4]. The idea is simple: keep the socket, but change the ball so the socket wears less.

THREE DESIGNS, THREE TRACK RECORDS

Pyrocarbon has been used in the shoulder in three ways, and their results are different enough that one should not be judged by another.

Design	How it works	Track record
Stemmed head	A pyrocarbon ball on a stem in the arm bone; the stem can stay if a later conversion is needed	The best results and most of the recent data
Resurfacing cap	A pyrocarbon cap fitted over the reshaped ball	Registry revision similar to good total replacements, but breakage of the cap was the leading reason for revision [5]

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Design	How it works	Track record
Interposition (PISA)	A loose pyrocarbon sphere placed between the arm bone and the socket	The weakest results: erosion of the arm bone and failures in unevenly worn sockets [6][7]

A 2026 analysis pooling 1,117 patients found high survival for stemmed pyrocarbon heads and lower survival for caps and interposition spheres [8]. A resurfacing cap has been reported to fracture after 6 years without injury, with no bone grown onto it [9]. Everything below is about the stemmed head unless it says otherwise.

WHAT THE CLINICAL SERIES REPORT

Study	Shoulders	Average follow-up	Free of revision	Notes
Garret 2019 [10]	65	2 years	95%	Multicentre, prospective
Cointat 2022 [11]	64	2.8 years	92%	Head not anatomic in 29%, with worse results
Hatzidakis 2026 [12]	157	2 years	3 revisions	US approval study, 18 hospitals
Kleim 2024 [13]	31	5.5 years	100%	1.4 mm of socket wear
Garret 2024 [1]	45	6.2 years	96%	13% lost to follow-up
Ranieri 2025 [14]	41	4.5 years	95%	Unevenly worn sockets, reamed at surgery
Griswold 2025 [15]	45	6.1 years	95.7% at 7 years	Prospective
Boileau 2026 [16]	103	5.6 years	94% at 5 years, 89% at 10	Largest single series
Hoy 2026 [17]	119	5 years	97.5%	One implant fracture
Droz 2026 [18]	27	2.7 years	93%	Socket wear progressed in 46%

Most patients in these series were working and active. In the two series from Nice, 91–92% returned to work and 88–93% to sport, and 88% of patients in the larger one were satisfied [11][16].

COMPARED WITH A METAL HALF REPLACEMENT

Every comparison published so far favours pyrocarbon over a metal ball:

- **Australian registry, under 55:** 8.9% of pyrocarbon caps had been revised by 6 years, against 17.1% of metal caps and 17.5% of metal stemmed half replacements [2].
- **US approval study:** 82.7% of pyrocarbon shoulders met the study's definition of success at 2 years, against 66.8% in an earlier group treated with metal heads [12].

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- **A Dutch private clinic:** 2.3% of pyrocarbon half replacements were revised, against 12.8% with metal heads, over up to 7 years [19].
- **Fractures of the top of the arm bone:** in people under 65, pyrocarbon heads gave better movement, less pain and better healing of the fractured bone than metal heads, although the stems used also differed [20].

COMPARED WITH A TOTAL SHOULDER REPLACEMENT

For a younger person with arthritis, the more relevant comparison is an anatomic total shoulder replacement. On revision rates, registries find no clear difference. In the Australian registry's 2025 report, among people under 60 with osteoarthritis, 6.9% of stemmed pyrocarbon half replacements had been revised by 5 years, against 5.9% of stemmed total replacements, 6.0% of stemless total replacements and 5.6% of reverse replacements; the differences were not statistically significant. Only 107 pyrocarbon shoulders had reached 5 years in that analysis, and 10 had reached 10 years (AOANJRR 2025 Annual Report, Table ST110).

- Pyrocarbon caps compared with the five best-performing total replacements in Australia: 7.7% against 9.0% revised at 10 years, with no difference in risk [5].
- In New Zealand, revision rates did not differ, but people who had a total replacement scored better on the Oxford Shoulder Score, by more than the smallest difference patients notice. The authors concluded that a total replacement remains the implant of choice for the best early function [21].
- In a matched comparison of 74 patients in each group, results at 2 years were similar. The total replacement group scored slightly better at 6 months and had slightly less pain at 2 years (0.45 against 1.06 on a 10-point scale) [22].

THE SOCKET STILL WEARS

Socket wear was the problem pyrocarbon was introduced to solve, and it is still the main reason these shoulders fail.

- A pooled analysis of 536 patients found socket erosion on X-ray in 22.8% [23].
- At about 6 years, wear was moderate in 24% of shoulders and severe in 8%, and 10 of 37 had worsened since surgery [1].
- In a series from another centre, wear progressed in 12 of 26 patients (46%) within an average of 2.7 years [18].
- The ball moved inwards by an average of 4 mm over 6 years in one series, and the space under the acromion narrowed in most patients [15].

Where wear was measured precisely, the amounts were small: 1.4 mm over 5.5 years in one series, most of it in the first year [13], and under 0.6 mm at 3 years on CT in another [24]. But wear matters when it happens. In the largest series, shoulders whose wear increased had more pain, worse function and lower survival (72% against 97%) [16].

Whether the material itself deserves the credit is debated. In a published letter, one surgeon argued that the pyrocarbon results resemble those of a metal half replacement combined with reshaping of the socket, and that the gains may come from patient selection and surgical technique rather than the material [25]. The authors

agreed they had no metal comparison group [26]. No study has yet compared the two materials with the same stem, technique and socket preparation.

REVISION DOES NOT CAPTURE EVERY POOR RESULT

Most studies count success as not needing another operation. A painful half replacement in a younger person is often not revised, so these figures can look better than patients' experience. In the US approval study, 26 of 146 shoulders (18%) did not meet the definition of success at 2 years, but only 3 of those had been revised; most of the rest had not improved enough on the Constant score [27]. In one series, two shoulders were revised for ongoing pain with no wear or tendon problem found [1].

GETTING THE SIZE RIGHT MATTERS

The results depend heavily on matching the new ball to the patient's own anatomy.

- In the largest series, the ball was oversized in 24% of shoulders. With an oversized ball, 25% needed revision, against 1.3% when the size was right [16].
- In an earlier series, a ball that was not anatomically placed (in 29% of shoulders) was linked to worse function and more complications [11].
- In another series, 46% of shoulders were overstuffed, and 7 of the 12 shoulders with worsening wear were among them. The authors noted that the metal disc under the pyrocarbon ball adds about 1.5 mm [18].

A surgical technique has been described to avoid overstuffing [28].

WHO SEEMS TO DO WELL

The best results have been reported in people with:

- a socket that is worn evenly rather than at the back;
- arthritis after earlier dislocations, or collapse of the ball from loss of its blood supply (avascular necrosis);
- healthy rotator cuff tendons, particularly the subscapularis at the front of the shoulder [7][29][15].

Small series after an earlier Latarjet stabilisation have also been encouraging [30].

The poorest results have been reported:

- with interposition spheres in sockets worn unevenly at the back, where 44% were revised, against 2% in evenly worn sockets [7]; in another series, 5 of 10 interposition implants were revised, all in this type of socket [31];
- with a torn or weak subscapularis tendon [7];
- when the ball is oversized [16].

Unevenly worn sockets treated with a stemmed head and reshaping of the socket have done well in one centre [14].

HOW STRONG IS THE EVIDENCE?

- **No randomised trials.** The studies are case series, cohorts compared with earlier patients, and registry analyses.
- **Short follow-up.** The pooled studies have a median of about 3 years [32], and few registry patients have reached 10 years.
- **Who did the studies.** Much of the data comes from the centres that developed the implants, from very experienced surgeons, or from manufacturer approval studies. One paper's consultancy and royalty declarations were added after publication in a correction [33][9].
- **Socket treatment.** Many patients also had their socket reshaped at the same operation, which makes it harder to tell what the material itself contributes [11][13][16].
- **Cost.** Pyrocarbon heads cost more than metal ones.

WHAT THIS MEANS

- Against a metal half replacement, the evidence consistently favours pyrocarbon.
- Against a total shoulder replacement, revision rates look similar so far, and early function and pain have been slightly better with a total replacement in two studies. The pyrocarbon option keeps the socket intact, which leaves more choices for later surgery.
- The socket can still wear, and how well the ball is sized matters a great deal.
- Long-term results beyond 10 years, and results outside specialist centres, are not yet known.

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