Treatment of Pisotriquetral Arthritis by Pyrocarbon Interposition Arthroplasty

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Abstract

Purpose Pisiformectomy is the baseline treatment for pisotriquetral arthritis when medical treatment fails to address the problem. This operation may lead to loss of mobility and strength in the wrist. This study reports the short-term outcomes of a new technique for treating pisotriquetral arthritis using a pisotriquetral interposition arthroplasty with a pyrocarbon implant.

Patients and Methods We performed a clinical and radiographic study on a series of eight patients who received this treatment at a mean follow-up of 2.8 years. We also studied the mobility of the implant and did assessed articular instability using dynamic radiology and fluoroscopy.

Results We observed one proximal dislocation of the implant in one hand which was reoperated to reposition the implant and strengthen the capsule. All patients were satisfied or very satisfied with their operation and had an average functional recovery period of 1.6 months. At the last follow-up, the Mayo Wrist Score (MWS), Quick Disability of Arm Shoulder and Hand (QDASH), and Patient-Rated Wrist Evaluation (PRWE) scores were 89, 18, and 20, respectively. Postoperatively, there was a 22% improvement in the grip strength of the wrists as well as improved mobility, mainly as regards the radioulnar deviation (47% improvement) and the Visual Analogue Scale (VAS) pain scores decreased from 8 preoperatively to 2 at the latest follow-up. The functional radiologic and fluoroscopic study reported good adaptive mobility of the implant in all the patients, without any indication of pisotriquetral joint instability.

Conclusion The short-term results of pisotriquetral arthroplasty using the Pyrocardan implant are encouraging. This new surgical solution appears to be a valid alternative to pisiformectomy or pisotriquetral arthrodesis. Long-term studies are required to confirm these preliminary findings.

Keywords

- arthroplasty
- wrist
- pisotriquetral joint
- pyrocarbon
- pyrocardan

Pisiformectomy is the “gold standard” surgical treatment for pisotriquetral arthritis, the alternative option being pisotriquetral arthrodesis. Pisiformectomy usually renders good outcomes,^{1–6} though several authors noted associated loss of

mobility of the wrist and decreased grip strength. The latter is a result of kinematic impairment of the first row of carpal bones, which occurs after surgical excision of the pisiform,^{7–12} which in spite of its small size, is the attachment site for many

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ligamentous and tendinous structures, whence its important role in hand and wrist function.

To overcome the drawbacks of pisiformectomy or pisotriquetral arthrodesis, we propose a new surgical technique: pisotriquetral arthroplasty with interposition of a pyrocarbon implant. The goal of this operation is to perform a noninvasive arthroplasty with pisotriquetral interfacing, which maintains the biomechanical and kinematic functions of the pisiform.

The purpose of this retrospective study was therefore to report the preliminary short-term outcomes of pisotriquetral interposition arthroplasty.

Patients and Methods

Implant

The Pyrocardan implant (Wright–Tornier SA, Monbonnot, France) was introduced in 2009 for the treatment of trapeziometacarpal arthritis and scaphotrapezotrapezoid osteoarthritis (► **Fig. 1**).^{13–15} This pyrocarbon implant has a rectangular shape, with rounded edges, and two cylindrical concave surfaces perpendicular to each other. The Pyrocardan implant is available in seven sizes, XXS being the smallest size and XXL, the largest. Whatever its size, the thickness at the center of the implant is 1 mm, while the thickness of the outer edges of the implant is proportional to its size.

Patients

The authors retrospectively enrolled all consecutive patients that underwent pisotriquetral arthroplasty using a Pyrocardan implant at two centers specialized in hand surgery. The patients were followed-up for a minimum of 12 months after their operation. An independent observer collected standard pre-, intra-, and postoperative data, and performed the clinical (subjective and objective) and radiographic assessments.

The series consisted of eight patients who underwent surgery between January 2012 and May 2016. Seven patients had surgery in the author's department and one of them in

another department. There was one man and seven women. The etiology was primary pisotriquetral osteoarthritis in seven cases, and posttraumatic osteoarthritis in a woman who had been suffering from a cerebellar syndrome for 20 years, causing her to fall repeatedly. Five patients were professionally active at the time of surgery. Five patients had received initial treatment consisting of an orthotic worn for 6 weeks to 6 months. Two women received intraarticular (IA) corticosteroid injections that markedly but only temporarily improved their symptoms for a period of 1 to 2 weeks.

Arthroplasty was performed by three surgeons specialized in hand surgery. The patients had surgery after having symptoms in their wrists that lasted for a mean period of 1.3 ± 0.9 years (range, 0.4–3). The smallest implant (XXS) was used in four cases, the XS size in three, and the S size in one. In one case, a neurolysis of the ulnar nerve at Guyon's canal was added. Closure of Guyon's canal was completed by means of a capsuloplasty using a 4/0 diameter slow resorption thread to strengthen the pisohamate and pisometacarpal ligaments. All the patients commenced autorehabilitation after the immobilization and none of them required physiotherapy rehabilitation (► **Table 1**). At final follow-up, all patients resumed their usual activities. The five professionally active patients all returned to work after 1.6 ± 0.9 months (range, 0.5–3).

Assessment

Subjective Assessment

Seven patients had follow-up visits and one of them was contacted by phone. The mean follow-up was 2.8 years (range, 12–44). The average age at the time of surgery was 60.5 ± 9 years (range, 51–74). The dominant hand was affected in 50% of the cases.

Patients were questioned about any symptoms they might have had in their wrists and hands after surgery. Sensitive subjective signs around the ulnar nerve were investigated. The level of pain was assessed using the Visual Analogue Scale (VAS) (0 being a total absence of pain and 10 maximal pain), the pain section of the Mayo Wrist Score (MWS), and lastly, according to four levels of pain: absent, intermittent, constant, and disabling. Two self-administered functional status questionnaires were used: the Quick Disability of Arm Shoulder and Hand (QDASH) and the Patient-Rated Wrist Evaluation (PRWE) questionnaires. Patients assessed their satisfaction as to the results of their surgery according to four levels: very satisfied, satisfied, partly satisfied, or dissatisfied. Finally, patients were asked whether or not they would go through the same procedure again in a similar context.

Objective Assessment

Postoperative assessment of the wrist included the following criteria: the aspect of the scar (suppleness, sensitivity, discomfort), the trophicity of the hand, the presence of edema, blockage, twitching of the ulnar nerve, the symptoms of flexor carpi ulnaris (FCU) tendonitis, the location of any pain, or paresthesia. The assessment also sought to detect ulnar palmar pain induced by full passive extension of the wrist and the opposition of the thumb to the 5th finger, as well as pain on

Fig. 1 The Pyrocardan implant.

Table 1 Demography and characteristics of the series

Patients	Sex	Age (at time of surgery)	Affected side	Occupation	Symptom period	Other osteoarthritis lesion on operated hand on contralateral hand
1	F	71	R ^a	Retired (caregiver)	5 mo	None TM operated and STT
2	F	74	L	Retired (keyboarder)	1 y and 2 mo	TM TM and MCP F2 operated
3	F	69	L	Secretary	1 y	SLAC 1 and TM None
4	F	53	L	Truck driver	2 y	TM None
5	F	55	R ^a	Invalidity (maternal assistance)	5 mo	None None
6	F	58	L	Domestic help	2 y	None TM
7	M	51	R ^a	Bike factor	6 mo	None None
8	F	54	R ^a	Artisan decorator	3 y	None Luno-triquetral arthrosis
Results	F = 87.5% M = 12.5%	60.5 ± 9	^a = 50%		1.3 y ± 0.9	

Abbreviations: F, Female; F2, 2nd finger; M, Male; MCP, metacarpophalangeal joint; SLAC, scapholunate advanced collapse; STT, scaphotrapezotrapezoidal joint; TM, trapeziometacarpal joint.

^aDominant hand.

application of pressure, mobilization, or anterior–posterior percussion of the pisiform. A series of tests were performed:¹⁶

- the friction test: Eliciting pain (with or without crepitus) in the pisotriquetral joint space by compressing and rotating the pisiform, with the wrist held in flexion.
- the apprehension test: The examiner mobilizes the pisiform laterally, with a neutral or slightly extended wrist, creating a feeling of apprehension in the patient who fears the pain and stops the maneuver.
- the stress test: The examiner inflicts ulnar-sided wrist pain when he uses his thumb to resist the proximal migration of the pisiform during the movement of the wrist from flexion to full extension.

A goniometer was used to measure flexion, extension, radial deviation (RD), ulnar deviation (UD), and pronation–supination (PS) mobility in both wrists. The grip strength of the wrist was measured on both sides using a hydraulic hand dynamometer with a handle (BASELINE, White Plains, NY). The readings were obtained in kilograms by using the mean of three strength tests for the resultant score. All patients underwent a Weber tactile discrimination exercise to assess sensitivity around the ulnar nerve. Lastly, we established the MWS for each patient based on the subjective and objective data.

Radiologic and Fluoroscopic Assessments

Radiographic assessment was based on sagittal view X-rays with a 30° to 45° supination of the forearm and the hand, and on conventional frontal and sagittal views.¹⁷ We classified pisotriquetral arthritis according to two etiologies:^{18,19}

- primary osteoarthritis: with no history of trauma and an aspect of osteoarthritis on the medical imaging examinations.
- secondary arthritis: due to a trauma or several micro-traumas. With radiographic abnormality such as a fracture or dislocation of the pisiform, or a fracture of the hamate bone, or without radiographic abnormality but evidence of an old trauma or repetitive microtrauma.

We noted the position of the implant (subluxation, dislocation) as well as any bone alterations (progression of osteoarthritis, bone densification around the implant, impaction, osteolysis, ossification, subchondral bone cyst, fracture). Lastly, the study of the stability of the implant and the pisiform was based on dynamic imaging and cinefluorography: a profile view of 30° to 45° supination during flexion/extension of the wrist and a front view of the radioulnar deviation movement.

We performed several radiological measurements as defined by Jameson et al with the wrist in neutral, flexion, and extension positions: pisotriquetral space, pisiform excursion, pisohamate distance, and pisotriquetral angle (► Fig. 2).¹⁷ Accurate measurements were made using the Mesurim software (<http://acces.ens-lyon.fr/acces/logiciels/mesurim/mesurim>) by calibrating and graduating the measuring scale to the constant central thickness of the implant of 1 mm.

Surgical Technique

All operations were performed as open surgical procedures using a pneumatic tourniquet and locoregional anesthesia. The

Fig. 2 Measurement parameters (in mm) of pisotriquetral joint instability performed on radiological incidences with a 30° to 45° supination profile.¹⁹ (A) 1 = measure of pisotriquetral space (in neutral wrist position): anteroposterior distance between a central point on the pisiform articular surface and another opposite point on the triquetrum articular surface. 2 = measure of pisohamatal space (in neutral wrist position): distance between the most hamulus proximal point and the most pisiform distal point. (B) 3 = measurement of pisiform excursion (in wrist extension): distance between the two parallel lines passing through the center of the articular surfaces of the pisiform and the hamatum, and perpendicular to the triquetral surface.

surgical approach was performed on the ulnar edge of the wrist by means of a curvilinear or broken line incision of approximately 3.5 cm next to the pisotriquetral space. The surgeon first located the FCU terminal tendon and then performed longitudinal arthrotomy on the ulnar edge of the pisotriquetral joint (→ Fig. 3).

After synovectomy and surgical removal of any osteochondral foreign bodies, the pisiform was raised and inclined on the radial side. A fine spatula was used to assess the state of the joint capsule, particularly its continuity at the proximal, distal, and medial aspects. After resection of any osteophytes, the abrasion of the arthritic joint surfaces was performed with an oscillating saw or a rotary burr so that the articular surfaces of the triquetrum and the pisiform were respectively slightly convex proximodistally and lateromedially. The trial implant was positioned to determine the most suitable size, and then static and dynamic fluoroscopic inspections were performed. Then the final implant was inserted and the joint capsule sutured using slow resorption thread with a diameter of 3/0. Should a loss of continuity, or proximal or distal capsular

fragility be observed, the joint could be strengthened by an intertwined nonabsorbable suture with a thread diameter of 0. After skin closure, fluoroscopic inspection was again performed and the wrist was immobilized in neutral position in a thermoformed orthotic worn continuously for 2 weeks. Progressive removal from the orthotic and gentle physiotherapy of the wrist was then recommended. Manual activities were allowed progressively authorized from the fourth postoperative week and full unrestricted activities were allowed from the sixth postoperative week.

Results

Subjective Results

Pain levels improved by an average of 6 points on the VAS which had been at 8 (range, 5–8) preoperatively and at 2 at final follow-up. Five patients no longer experienced any pain, whatever activity they engaged in. Three patients experience intermittent ulnar pain only if they carried a heavy load in forced supination and UD (VAS between 2 and 5 during this

Fig. 3 Surgical technique. (A) Surgical approach of the pisotriquetral joint drawn in dotted line. Above the dotted line is represented, in continuous line, the ulnar side of the pisiform with the flexor carpi ulnaris (FCU) insertion. Below the dotted line is represented schematically the thickness of the triquetrum articulating with the pisiform. (B) Implant set up in the pisotriquetral joint. (C) Capsular closure of the pisotriquetral joint.

Table 2 Postoperative clinical results of the series

Patients	Pain (VAS)	Mobility (% of ROM of affected side/CL)	Strength grip in kg (%/CL)	Satisfaction	Scores (preop value) MWS QDASH PRWE
1	Absent (0)	F/E = 85°–60° (100%) RI/UI = 20°–50° (116%)	28 (140%)	Very satisfied	100 9.1 4
2	Absent (0)	F/E = 80°–70° (90%) RI/UI = 0°–60° (100%)	18 (100%)	Very satisfied	100 9.1 2
3	Intermittent (5)	F/E = 70°–60° (96%) RI/UI = 10°–50° (120%)	28 (140%)	Satisfied	75 47.7 (65.9) 58.5 (75.5)
4	Intermittent (2)	F/E = 50°–65° (85%) RI/UI = 35°–50° (100%)	30 (86%)	Very satisfied	65 40.9 43
5	Absent (0)	F/E = × RI/UI = ×	×	Very satisfied	×
6	Absent (0)	F/E = 70°–70° (100%) RI/UI = 35°–50° (121%)	20 (133%)	Very satisfied	100 18.2 (75) 8.5 (83.5)
7	Absent (0)	F/E = 75°–50° (100%) RI/UI = 20°–50° (100%)	45 (112.5%)	Very satisfied	100 13.6 4
8	Intermittent (5)	F/E = 50°–55° (95%) RI/UI = 10°–20° (75%)	10 (55.5%)	Very satisfied	70 20.5 (63.6) 56.5 (73)
Results	VAS = 2 62.5% painless	F/E = 70°–63° (99%) RI/UI = 21°–51° (111%)	27 ± 9 (113%)	87.5% Very satisfied 12.5% Satisfied	MWS = 89 ± 15 QDASH = 18 ± 17 PRWE = 20 ± 21

Abbreviations: CL, contralateral; E, extension; F, flexion; MWS, Mayo Wrist Score; PRWE, Patient-Rated Wrist Evaluation; QDASH, Quick Disability of Arm Shoulder and Hand; RI, radial inclination; ROM, range of motion; UI, ulnar inclination; VAS, Visual Analogue Scale.

Note: × = no data.

maneuverer). None of the patients had paresthesia in the ulnar nerve territory (► **Tables 2** and **3**).

The mean PRWE score improved by 58 points (74%) passing from 78 ± 42 (range, 73–83.5) preoperatively to 20 ± 21 (range, 2–58.5). The mean QDASH score improved by 50 points passing from 68 ± 6 preoperatively to 18 ± 17 (range, 4.5–47.7) at final follow-up. The MWS at the time of the review was at 89 ± 15 (range, 65–100).

All patients were either very satisfied (seven patients) or satisfied (one patient) with their operation and were all prepared to undergo surgery again if need be.

Objective Results

The mean flexion–extension mobility was improved by 5° in flexion despite a mean extension loss of 1°. It was $128^\circ \pm 67^\circ$ ($65^\circ \pm 9^\circ$ in flexion, $63^\circ \pm 6^\circ$ in extension) preoperatively, which corresponds to 95% on the contralateral side. At final follow-up, it was $133^\circ \pm 48^\circ$ (70° in flexion $\pm 12^\circ$ and 63° in extension $\pm 7^\circ$), which corresponded to 99% on the contralateral side (► **Tables 2** and **3**).

The radioulnar deviation gained 30°. Preoperatively, the mean radioulnar deviation was $42^\circ \pm 24^\circ$, namely, 64% on

the contralateral side ($12^\circ \pm 3^\circ$ in RD, $30^\circ \pm 10^\circ$ in UD). At final follow-up, it was $72^\circ \pm 27^\circ$, which represents 111% on the contralateral side ($21^\circ \pm 13^\circ$ in RD, $51^\circ \pm 4^\circ$ in UD).

Mobility in PS was unchanged, and it was symmetric on the contralateral side for all the patients.

The grip strength increased by 5 kg. Preoperatively, it was 22 ± 10 kg, which represents 91% on the contralateral side. At final follow-up, it was 27 ± 9 kg, which represents 113% on the contralateral side. All the clinical maneuverers for the direct or indirect mobilization of the pisotriquetral joint were painless. All the patients had a normal Weber test and pliable scars.

Radiologic and Fluoroscopic Assessments

All patients were evaluated radiographically but cinefluorographic analysis could only be performed for three patients. During flexion–extension, mobility was greater between the triquetrum and the implant, and then between the pisiform and the implant. During the radial–ulnar deviation, the bony superpositions did not allow for an accurate analysis.

None of the eight patients showed signs of static or dynamic pisotriquetral joint instability. The pisiform excursion was

Table 3 Summary of preoperative and postoperative results of the series

Patients	Preoperative (%/CL)	Postoperative FU = 2.8 y (%/CL)	Gain pre-/postop (% of gain)
F	65° (89)	70° (96)	
E	63° (102)	63° (101)	
ROM F–E	128° (95)	133° (99)	+ 5° (4) $p = 0.8$
RI	12° (71)	21° (126)	
UI	30° (62)	51° (106)	
ROM RI–UI	42° (64)	72° (111)	+ 30° (47) $p = 0.3$
Strength grip (kg)	22 kg (91)	27 kg (113)	+ 5 kg (22) $p = 0.2$
Pain VAS	8	2	–6 (75) $p < 0.5$
QDASH	68	18	–50 (74) $p < 0.5$
PRWE	78	20	–58 (74) $p < 0.5$
MWS	57	89	32 (56) $p < 0.5$

Abbreviations: CL, contralateral; E, extension; F, flexion; FU, follow-up; Grip, hand clamping force; MWS, Mayo Wrist Score; postop, postoperative; preop, preoperative; PRWE, Patient-Rated Wrist Evaluation; QDASH, Quick Disabilities of the Arm, Shoulder and Hand; RI, radial inclination; ROM, range of motion; UI, ulnar inclination; VAS, Visual Analogue Scale.

close to normal; however, the pisohamate distance was slightly shorter (►Fig. 2, ►Table 4). The height of the pisotriquetral space, measured after arthroplasty, was comparable to that of healthy joints, 1.5 mm in the neutral position, 1 mm in extension, and 2.5 to 3.5 mm in flexion.^{17,20} The pisotriquetral angle was not measurable, as it was distorted by the

implant, which had a tendency to make the two joint surfaces parallel to each other.

Two proximal subluxations of the implant, of approximately one-third of the size of the implant, were discovered 1.5 and 6.5 months, respectively, after the operation. These did not progress at follow-up and were perfectly well tolerated clinically. No abnormalities were observed in the periarthicular bones of the patients.

Complications and Reoperations

During the first clinical X-ray examination, an early spontaneous proximal dislocation of the implant was observed in one patient 1 month after surgery, which required reoperation to reposition the implant and strengthen the proximal capsule by lacing it with a Goretex CV 0 diameter thread (►Fig. 4). The postoperative protocol was identical for this new operation. The patient, who was a 50-year-old right-handed postman, was able to return to work, and the result at final follow-up of 12 months was excellent, with symmetrical mobility in the wrist, a force of 45 kg (112% on the contralateral side), a VAS score of 0, a PRWE score of 4, a QDASH score of 13.6, and a MWS score of 100. From a radiologic point of view, the dynamic imaging process and the fluoroscopic functional evaluation showed that the implant was centered (►Video 1).

Video 1

Cinefluoroscopy on lateral view during wrist extension to flexion of the pisotriquetral pyrocarbon arthroplasty at the last follow-up of the patient of ►Fig. 4. Online content including video sequences viewable at: www.thieme-connect.com/ejournals/html/doi/10.1055/s-0037-1612635.

Discussion

We reported the results of an original technique of pisotriquetral arthroplasty using a pyrocarbon interposition implant. In our series of eight patients at a 2.8-year follow-up, the preliminary clinical and radiological results are encouraging. Primary pisotriquetral arthritis was the prevalent medical condition diagnosed. All patients were very satisfied or satisfied with the outcome of the surgery in regard to pain and wrist function. Wrist strength had improved as well as range of motion, mainly in deviation. One month after the operation, a proximal dislocation of the implant needed reoperation and recovered successfully using the same technique.

Until present, there were only two options for the surgical treatment of pisotriquetral osteoarthritis: pisiformectomy and pisotriquetral arthrodesis. Pisiformectomy is the oldest and most widely used technique with results that are considered to be satisfactory on the whole. Recent studies, however, have discovered a long-term 5 to 20% loss of active extension in the wrist.^{11,12} Our series only finds a 1% extension loss at follow-up of 2.8 years, which is comparable with

Table 4 Radiological results of pisotriquetral joint mobility

	Values at last follow-up	Normal values ^a
Pisotriquetral space		
Neutral wrist	1.4 mm ± 0.3	1.5 mm (1–2 mm)
Wrist flexion	2.3 mm ± 1.1	3.5 mm (2–6 mm)
Wrist extension	1.4 mm ± 0.5	1 mm (0–1.5 mm)
Pisiform excursion	5.1 mm ± 2.4	6 mm (3–10 mm)
Pisohamatale space		
Neutral wrist	3.8 ± 2.2 mm	7.5 mm (4–10 mm)
Wrist flexion	–0.8 ± 2.5 mm	2 mm (–1 to 6 mm)
Wrist extension	4.6 ± 2.5 mm	8 mm (.5–11 mm)

Abbreviation: mm, millimeter.

^a19.

Fig. 4 X-rays of manual worker who had an implant dislocation. (A) Preoperative X-ray. (B) X-ray with dislocated implant, 1 month postoperative. (C, D) X-rays after reoperation, at 12 months of follow-up.

the results found in the medical publications at the same follow-up.^{5,21} Several studies found a loss of strength of up to 30% in the medium to long term.^{5,6,11,12,22,23} Our series, on the other hand, has noted an increase in the wrist strength of all our patients. Moreover, the outcome of a pisiformectomy in terms of pain, may be incomplete with 50% of patients on average being pain-free 3 years after the pisiformectomy and 85% being pain-free at 10-year follow-up.^{2,3,5,6,11,18,21-24} In our series, 62.5% of patients were completely pain-free at less than 3 years' follow-up. Finally, ulnar nerve damage at Guyon's canal may appear following pisiformectomy, a complication that we did not encounter in our series.⁵

The study of van Eijzeren and Karthaus is the only one that reports DASH and MHOQ (Michigan Hand Outcomes) scores to assess wrist functionality after a pisiformectomy.¹² In this study, the DASH score was 32 at 10 years, the QDASH score of our series was 18 at 2.8 years.

Pisotriquetral arthrodesis is far less frequently performed option. There are few published series with small samples, sometimes only comprising a single clinical case and a young and active patient, such as that Abrams and Tontz in 2006, and Singer et al in 2011.^{25,26} Pisotriquetral arthrodesis is a more complex operation than pisiformectomy. It carries the risk of pseudarthrosis, impingement between the pisiform and the ulnar head, and a loss of mobility.^{10,25} Furthermore, it requires a longer immobilization period: 2 to 3 months immobilization for an arthrodesis as against 2 to 4 weeks for a pisiformectomy.^{10,25}

The pisotriquetral arthroplasty that we propose is a new option for the treatment of pisotriquetral arthritis. It is a logical concept, as this technique preserves the pisiform, the anatomy, and the biomechanics of the pisotriquetral joint, which are essential for the maintenance and proper distribution of force across the carpus.^{27,28} The pisiform can in fact be considered as a patella-like bone since it acts as a lever arm which increases the mechanical advantage of the FCU transmitted to the carpus to bend and incline the wrist.^{8,10,11} This action also stabilizes

the first row of the carpus. Lastly, the pisiform protects the ulnar nerve as it passes through the Guyon's canal.

The articular surface of the triquetrum is slightly convex and its average size is 11 mm × 9 mm. The surface of the pisiform is slightly concave and more oval-shaped with an average size of 10.5 mm × 8 mm.^{8,29} The pyrocarbon interposition implant (Pyrocardan) matches the ellipsoidal shape of the pisotriquetral joint. The size of the smallest implant (XXS) used in the majority of cases, is 11 mm × 9 mm. Moreover, the space required for this implant is limited as its thickness at the center is always 1 mm, whatever the size of the implant. Consequently, the height of the pisotriquetral space after the arthroplasty was not compromised.

Twelve ligamentous or tendinous attachments ensure the stability of the pisiform, and the tensioning of these attachments during wrist movement gives it a wide range of motion.^{8,30,31} Movement takes place in a proximodistal and ulnar radial direction.³⁰ This allows for the stabilization of the triquetrum and prevents palmar subluxation of the pisiform in extreme wrist extension. Thus, the pisotriquetral space widens in wrist flexion and narrows in wrist extension. The articular surface of the pisiform moves respectively more proximally and more distally than the articular surface of the triquetrum.³⁰

The present study demonstrates that pisotriquetral arthroplasty did not alter the position or the kinematics of the pisiform in the sagittal plane. The proximal distal excursion of the pisiform in relation to the triquetrum was comparable to the standard established by Jameson et al.¹⁷ However, our kinematic analysis is incomplete due to bone superpositions, which limited reliable analysis to the frontal plane. A study based on computed tomography (CT) would be a useful complement.

We reoperated one patient with a case of proximal luxation of the implant. Two other implants were proximally subluxated, both were functionally well-tolerated and did not require reoperation. These instabilities may be attributed to a technical

intraoperative error, in which the defective proximal capsule was not assessed and not repaired. The exploration of the pisotriquetral joint under arthroscopy which was performed in Arya et al's study by 6R radiocarpal approach, showed that in approximately 75% of cases, the proximal joint capsule could easily be penetrated either due to its pellucidity or directly by a more or less extensive spontaneous fenestration.³² We recommend that, during operation, this weakness in the joint be assessed with the aid of a spatula and, in the case of capsular fragility or dehiscence, it should be strengthened with a nonabsorbable braided suture to avoid instability of the implant at a later stage.

In our opinion, pisotriquetral arthroplasty is a valid alternative to pisiformectomy or pisotriquetral arthrodesis. If the arthroplasty operation should prove to be unsuccessful, it is always possible to perform either of the other two techniques. This technique seems advisable to us in the case of primary pisotriquetral osteoarthritis and in the vast majority of refractory secondary pisotriquetral osteoarthritis cases. It is particularly suitable for young patients and those who require considerable grip strength (athletes and manual workers).

The short series and follow-up period are the main limitations of this study. As well as the mean age of the patients (60.5 years $\pm$ 9 years in our series), which is older than the mean age in the series for other techniques. The mean age was 45 years $\pm$ 5.4 (range, 40–54.8 years) for the pisiformectomy series, and 22.4 years $\pm$ 6.7 (range, 14–30 years) for the arthrodesis series.^{2,5,6,11,12,21–26,33} The patients' age can be a bias in the assessment of pain and function. Lastly, rheumatoid arthritis in the hand and wrist increases and progresses with age, as our study has shown (**Table 1**).

Finally, as is the case in most published studies, we measured the grip strength of the wrist. But as regard to pathologies of the pisiform, it would be more appropriate to also measure wrist flexion strength which can be assessed using a specific device (BTE work simulator) that is only available in a few centers.^{11,34,35}

Conclusion

Pisotriquetral arthroplasty by pyrocarbon interposition implant (Pyrocardan) preserves the anatomy of the pisotriquetral joint and the adaptive mobility of the pisiform. It provides pain relief and enables wrist strength to be maintained. It is a simple operation, with little or no iatrogenic effect, allowing for a rapid return to functionality and the recourse to other surgical techniques in case of failure. The short-term results of the small present series are encouraging and suggest that the technique is a valid alternative to the pisiformectomy or pisotriquetral arthrodesis. Studies on larger series, with younger patients and over a longer follow-up are required to definitively validate this new therapeutic proposal.

Conflict of Interest

P.B. has a conflict of interest to disclose with Tornier/Wright medical company. Other authors have nothing to disclose.

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