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Original article

Double trapeziometacarpal and scaphotrapeziotrapezoidal pyrocarbon interposition implants for pantrapezial arthritis: Midterm results and surgical technique

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ABSTRACT

Background: Pantrapezial osteoarthritis of the thumb (OA) includes involvements of scaphotrapezoid-trapezoidal (STT) and trapeziometacarpal (TM) joints which are source of disabling pain and function loss. Whilst radical procedures or arthroplasties are available, more conservative techniques have been developed recently and have gain popularity. They aim of this study was to know the midterms results of patients presenting peritrapezial OA treated with a double interposition pyrocarbon implant at the STT and TM joints. Our hypothesis was that patients suffering from pantrapezial OA treated with this technique would improve their functional scores at the last follow-up.
Patients and Methods: This descriptive, retrospective, observational study analysed 31 patients treated with a double STT and TM pyrocarbon interposition implant ("Burger arthroplasty") between 2009–2018. Patients were clinically and radiologically diagnosed with pantrapezial OA before surgery (Eaton stage I or II). The primary endpoint was the comparison of the preoperative and postoperative values of the functional scores QuickDASH and PRWE. Epidemiological data and radiological results were reported. Pain, range of motion, pinch and grip strength, were analysed with standardised tools. The surgical technique was described in detail and reinforced with a didactic supplementary video.
Results: Eighteen patients were available for analysis (58%) with a mean age of 62 years (range: 49–79). At last follow-up (44 months, range: 9–95) we found significant reduced pain, significant improvement of QuickDASH and PRWE scores and of pinch strength ($p < 0.05$). Range of motion, grip and pinch strength did not improve significantly ($p > 0.05$). Two patients required revision surgery.
Discussion: The double STT and TM pyrocarbon interposition offer good results at midterm on patient suffering from early stages of pantrapezial OA with preserved trapezium structure.
Level of evidence: IV.

1. Introduction

Scaphotrapezoidtrapezoidal (STT) and trapeziometacarpal (TM) osteoarthritis (OA) are associated in around 90% of cases and are responsible of pain and loss of motion of the thumb [1–4]. The most popular treatment of this condition after failed medical treatment (splinting, anti-inflammatory infiltration, pain killers and/or non-steroidal anti-inflammatory drugs) is trapezial excision associated or not to ligament reconstruction or/and suspension-interposition arthroplasty [2,5]. However, this treatment requires a long time before recovery and complications such as thumb weakness, tendon irritation, scaphometacarpal impingement, carpal instability or tendon interposition herniation have been reported [6]. To palliate those drawbacks, more recent and less invasive procedures have been proposed and include open approaches, or arthroscopic techniques used for total or partial bone resection ("resurfacing"), bone fusion, bone replacement, joint replacement and biological or synthetic suspension-interposition arthroplasties [7–16].

Pyrocarbon was developed in the fifties and its indications in the medical field have largely progressed due to its mechanical, biological and tribological properties that make it a convenable source of articular implants particularly in hand surgery [17,18]. Such implants have been proposed to replace the trapezium or to be used as interpositions at the STT or TM joints offering good clinical and radiological results [12,13,19–24,41–44].

In this study, we proposed to combine two interposition pyrocarbon implants for the treatment of peritrapezial OA with a conserved trapezium (no radiological core damage) to preserve the trapezium and therefore the length of the thumb and maintain its biomechanics.

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We presented the detailed technique of a double TM and STT pyrocarbon interposition for the treatment of peritrapezial OA. This technique is called "Burger arthroplasty" as the trapezium is taken in sandwich between two pyrocarbon interpositions implants like a piece of meat in a burger. Finally, we present the midterms results of patients presenting peritrapezial OA treated with this technique. The hypothesis was that this technique offers good clinical and radiological results in patients suffering from of peritrapezial OA Eaton stage I or II.

The aim of this study is to answer three questions:

- are the functional results of patients treated with this technique improved after surgery?
- what are the complications of this technique?
- what are the contraindications of this technique?

After answering these questions, we propose a supplementary detailed video of this technique.

2. Methods

This descriptive observational retrospective monocentric study included 31 consecutive patients treated with a "Burger arthroplasty" between 2009 and 2018 operated by a senior surgeon [27]. It followed the STROBE guidelines. All patients presented clinical symptoms of STT and TM OA. Before surgery, they received conservative treatment including intraarticular infiltrations, nonsteroidal anti-inflammatory medication and thumb immobilisation. The radiological diagnostic was based on Kapandji's anteroposterior and lateral views, which confirmed the STT and TM OA [25]. Surgery was decided once the symptoms were insufficiently controlled by conservative treatment and if patient suffered of disabling symptoms at the examination of the STT and TM confirmed by radiological involvement of those joints (Eaton stage I or II). Patients presenting subchondral bone cyst or geodes of the trapezium on standard radiographs were excluded due to the risk of bone collapse.

Demographical data included age, sex, and follow-up. The primary endpoint was the comparison of preoperative and postoperative pain and QuickDASH and PRWE scores at the last follow-up. Secondarily, we analysed range of motion (ROM) based on the Kapandji scale [26], grasp and pinch strength measured with standardised dynamometers, minimal and maximal visual analogue pain scale (VAS), patient satisfaction, and complications. The radiological results were analysed based on Kapandji's anteroposterior and lateral views [25].

All patients were informed and their consented to participate to this study.

2.1. Implant description

The Pyrocardan ® (Wright) implant was used in this study. This pyrocarbon implant has a rectangular shape with biconcave and perpendicular surfaces. It has a fixed central thickness of 1 mm while the exterior edges are proportional to the implant size. It is available in seven different sizes ranging from 12 mm (XXS) to 18 mm (XXL) wide [18].

2.2. Surgical technique (Supplementary video)

A specialized consultant in hand surgery with an expertise level 5 performed all interventions [27]. Patients underwent surgery under locoregional anaesthesia in supine position with an arm tourniquet inflated at 250 mmHg. First, the TM joint was accessed through a dorsal approach as described in previous articles [18,21]. Subcutaneous divisions of the dorsal sensory radial nerve were protected and the extensor pollicis longus and extensor pollicis brevis were freed to access to the TM capsule on the medial border of the extensor pollicis brevis. The articular capsule was opened longitudinally delimiting two capsuloperiosteal flaps. At this point, the dorsal and palmar metacarpal bony beaks as well as the lateral and medial trapezium bony horns were removed. The metacarpal was then burred to achieve a spherical convexity with a homogenous surface while the trapezium was burred to shape a dorso-palmar convexity. The definitive implant was inserted after testing the trial implant under fluoroscopy for static and dynamical stability without articular tautness. The size of the implant was defined as the best implant that covers the subchondral trapezium bone completely. The capsuloperiosteal flaps were finally sutured by using a resorbable anchor fixed into the first metacarpal (Fig. 1).

A palmar approach was used to access the STT joint as described by Gauthier et al. [19]. First, a cutaneous incision of about 4 cm was made over the flexor carpi radialis (FCR) above the scaphotrapezial space. The sheet of the FCR tendon was opened and any degenerative tenosynovitis or cyst were removed. The articular capsule was opened longitudinally between the distal flange of the FCR, the tubercle of the scaphoid and trapezium. Under axial traction of the thumb the STT space was distracted and the articular surfaces of the trapezium and scaphoid were resected and homogenised with a surgical burr taking care to preserve the ligamentous attachment of the distal scaphoid. The lateral and medial edge of the trapezium were removed and the trapeziotrapezoid surfaces were blurred to create a convex subchondral surface. The aim at this stage is to preserve the natural convexity of the scaphoid and to create a slight mediolateral and anteroposterior convexity of the trapeziotrapezoid surfaces. It is important that the surface of the scaphoid is preserved and maintain its kinematics without pressure on the degenerative trapezoid surface. This requires a tailor-made resection of the trapezoidal surface for the implant to cover its surface. It is important that the surface of the scaphoid is preserved and can maintain its kinematics without having a strong contact on the trapezoid osteoarthritic surface. Depending on the case, this requires a more or less significant resection of the trapezoidal surface and the need for an implant covering this surface. Peroperative direct visualisation with by using a trial implant coupled with dynamic and static fluoroscopic evaluation makes it possible to check this technical point and make the final choice regarding bone resection and implant size. The trial implant was placed with its long axis mediolaterally and its concavity facing the trapeziotrapezoid surfaces. It was tested perioperatively for stability and complete coverage of the STT surfaces under fluoroscopy in wrist flexion/extension and ulnar/radial deviation. Finally, the definitive implant was placed between the scaphoid and the trapezium, the articular capsule was closed, and the skin was sutured with a resorbable running intradermal suture (Fig. 1). Patients were immobilised with a thumb splint for 2 weeks and only overnight for two consecutive weeks whilst active motion was encouraged during the day.

Descriptive quantitative data are expressed as mean and standard error of the mean (SEM) with it minimal and maximal values (min-max). Qualitative data are expressed as numbers and percentages. Student *t*-test was used to compare preoperative and postoperative results. The threshold of significance was set at 5% ($\alpha = 0.05$). All images were obtained via a digital image acquisition device.

3. Results

Thirty-one patients were operated between 2009 and 2018. From the thirty-one patients, 28 (90%) were reached and thirteen

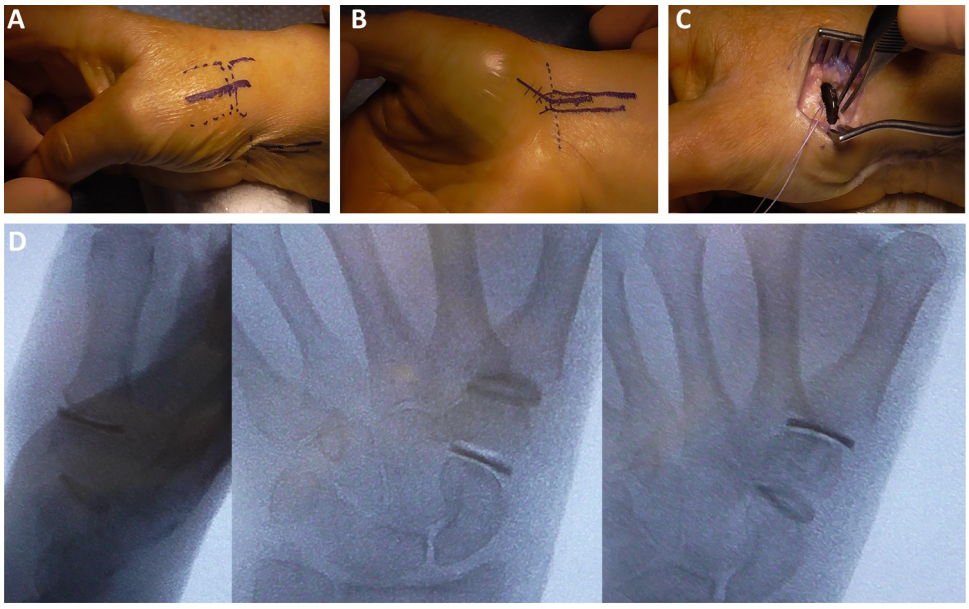

Fig. 1. Perioperative pictures and fluoroscopic images. (A) Dorsal approach to the trapeziometacarpal (TM) joint. (B) Palmar approach to the scaphotrapezoidtrapezoidal (STT) joint. (C) Placement of the definitive TM implant and metacarpal anchorage of the articular capsule.

were excluded (42%): ten patients were lost to follow-up (three patients were unreachable, two patients refused to be included, and five patients had health or social condition that did not allow them to participate). The three remaining excluded patients were unable to come to the last follow-up visit but they sent us their QuickDASH and PRWE. From the excluded cases, on one was bilateral. As no clinical and radiological data was available for those patients their data was excluded. Eighteen patients (19 thumbs) were available for analysis with complete postoperative data: fourteen females (78%) and four males (22%) with a mean age of 62 years (range: 49–79, SEM 2.1). In 8 cases the dominant hand was operated. One case was bilateral. The mean follow-up was 44.3 months (range: 9–95, SEM 5.9).

Regarding the primary endpoints, significant improvements were observed on the QuickDASH, PRWE and VAS (at rest and maximal pain) ($p < 0.05$) (Table 1). The mean QuickDASH and PRWE improved from 68.4 (range: 50–93.2, SEM 4.5) and 70.9 (range: 54.5–83.0, SEM 4.0) preoperatively, to 27.7 (range: 2.3–72.7, SEM 5.1) and 24.8 (range: 0.0–63.5, SEM 5.4) ($p < 0.05$) postoperatively respectively. The mean Kapandji scale improved from 9.3 preoperatively to 9.6 ($p = 0.4869$) at last follow-up (Fig. 2). All patients but two (11%) were satisfied with the surgery. Two patients developed a complex regional pain syndrome (CRPS). One patient presented a Z deformity with 32° hyperextension of the metacarpophalangeal joint.

Radiologically, there was not any sign of carpal instability or foreign body reaction (Fig. 3). One patient presented a complete spontaneous migration of the implant at the TM level without any clinical consequence. One patient presented remodelling of the base of the metacarpal.

3.1. Revisions

Two patients needed surgical revision. The first patient presented a posttraumatic migration after a fall on the extended wrist and underwent revision surgery, trapezium excision and removal of the two implants (TM and STT) in another centre. A second patient required revision 13 months after surgery due to spontaneous trapezium collapse and underwent trapeziectomy.

4. Discussion

The choice of the surgical treatment of pantrapezial OA is difficult as there is no consensus between the current techniques [28]. Classical treatments of this condition are trapezium-sacrificing techniques with or without ligament reconstruction and/or suspension arthroplasty disregarding the involved joints [28,29]. However, with better understanding of the degenerative pantrapezial disease, the development of new materials and less invasive techniques, new surgical options have been reported and are currently being evaluated [12,13,19–22,30,31,41–44].

The aims of a surgical technique treating trapezial OA have been described by Bodin et al. and include 1) removal of the articular surfaces, 2) preservation/reconstruction of the ligaments and 3) preservation of the joint spaces [32]. In fact, the ligamentous structures around the trapezium and the thumb length play an important role in carpal and thumb stability [30,33].

Therefore, preservation of the anatomy and particularly of the soft tissues are the principles of our technique. We believe that conservation of the length of the thumb is of paramount importance for stability, motion, pinch and strength. Additionally, maintaining the articular spaces avoid thumb shortening and subsidence of the first metacarpal in the scaphoid which occurs after trapeziectomy particularly in patients with general hyperlaxity [33]. Such disturbances of thumb anatomy can lead to disability due to metacarpophalangeal hyperextension, reduced strength and limited range of motion [34].

In our study, the postoperative pinch strength was of 6.1 kgf, grip strength was 23.8 kgf and range of motion was 9.6 which demonstrates good thumb although the improvement was not signification compared to the preoperative values. These results are comparable with those of Cobb et al. and Rubino et al. who proposed similar conservative trapezium-preserving techniques [15,16]. The former authors proposed arthroscopic resection arthroplasty with or without interposition of Graft Jacket (Wright Medical Technology Inc., Arlington, USA) and showed improvement on the grip strength form 16.4 kgf preoperatively to 21.8 at one-year follow-up whilst the pinch strength improved of 1.3 kgf. However, given the arthroscopic approach their technique requires an important learning curve and authors reported 4 cases

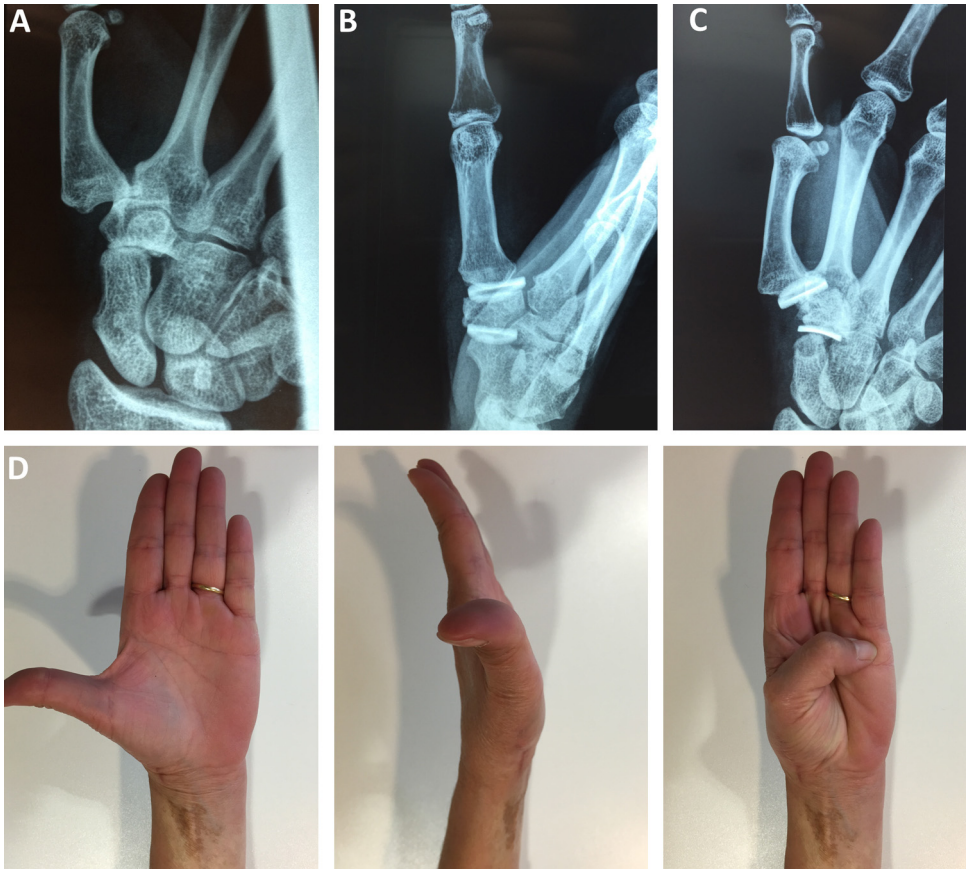

Fig. 2. Preoperative and postoperative radiological and clinical results at 6-month follow-up. (A) Preoperative lateral view showing trapeziometacarpal (TM) and scaphotrapezoidtrapezoidal (STT) osteoarthritis. (B) Postoperative radiological anteroposterior view. (C) Postoperative radiographical lateral view. (D) Clinical results showing complete range of motion and opposition of the thumb (Kapandji 10).

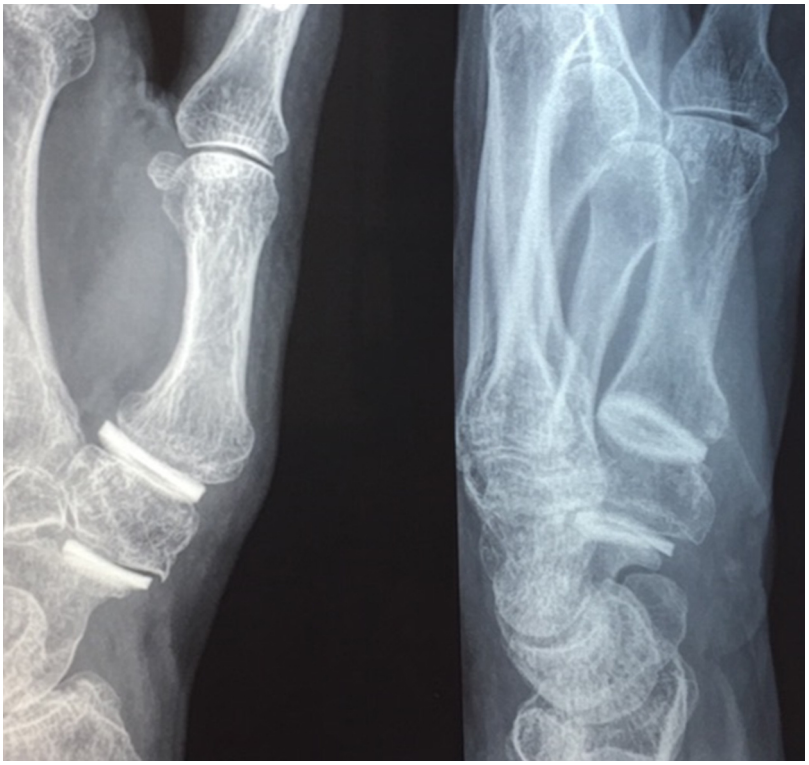

Fig. 3. Radiological result at the highest follow-up (95 months) showing stable implants and no signs of intolerance.

Table 1
Preoperative and postoperative clinical results.

	Preoperative			Postoperative			
	Mean	SEM	n[a]	Mean	SEM	n	*p*
QuickDASH	68.4	4.1	10	27.7	5.1	18	< 0.0001*
PRWE	70.9	3.7	10	24.8	5.4	18	< 0.0001*
ROM (Kapandji)	9.3	0.8	4	9.6	0.3	19	0.4869
Grip strength (kgf)	17.8	1.0	5	23.8	2.0	19	0.1498
Pinch (kgf)	4.0	0.4	5	6.1	0.5	19	0.0384*
VAS at rest	3.8	0.3	10	0.6	0.3	19	< 0.0001*
Maximal VAS	9.1	0.3	10	4.2	0,8	19	0.0003*

Data show mean and standard error of the mean (SEM). QuickDASH: Quick version of the Disabilities of the Arm Shoulder and Hand questionnaire. PRWE: The Patient-Rated Wrist Evaluation questionnaire. VAS: visual analogue scale.
[a] Data was unavailable preoperatively for some patients.
* $p < 0.05$.

of revision due to infection or tendinitis. Other drawback of this technique is the fact that an eventual degenerative tenosynovitis of the flexor carpi radialis cannot not be treated arthroscopically.

A similar conservative technique is proposed by Rubino et al. [15]. By using an open approach, the surfaces of the TM and scaphotrapezial joints are resected to create a narrow fibrous pseudarthrosis. In a 5-year follow-up they found improvements in the DASH score from 65 to 8.7 and the pinch strength from 24.6 N (2,4 kgf) to 55.2 N (5.6 kgf). This technique requires K-wire fixation between the joints, which can be source of stiffness, migration or infection. Finally, even if concerns exist regarding the long-term stability of the fibrous tissue created around the joints and the risk of fusion between the bones, this technique seems promising and we hope to see soon comparative and long-term studies.

Yeoman et al. presented a very long-term outcomes (mean follow-up of 8.2 years) of simple trapeziectomy and found a mean QuickDASH score of 40 [35]. With a mean QuickDASH score of 27.7 our results are rather satisfactory compared to the aforementioned study and to the normative values proposed by Aasheim and Finsen for the same age group [36]. However, we present a midterm follow-up of 4 years and our population was reduced to pantrapezial OA whilst Yeoman et al. included patients presenting TM OA with no further details about the STT involvement and no information is provided regarding grip and pinch strength [35].

Our articles diverges with the latest review published by Gottschalk et al. which recommends trapezium sacrificing techniques for pantrapezial OA [28]. We believe that several stages of pantrapezial OA exist and therefore specific techniques should be proposed to each. For instance, in our study we observed one trapezium collapse on a patient presenting an intraosseous cyst in the trapezium. Our technique should be therfore limited to the treatment of early stages of pantrapezial OA where the structure of the trapezium is preserved and there are no signs of trapezium collapse or intraosseous cyst (which represent late stages of pantrapezial OA). Those different stages of the disease have not been evaluated before and we hope that with the development and availably of CT-scan future studies will investigate in detail the stages and evolution of this disease.

In our study we used a double approach, a palmar approach to access the STT joint and a dorsal approach for the TM joint (Fig. 1). It is important to diagnose the combined OA of the STT and TM leveles before carrying this procedure as a more conservative treatment can be offerd to patient suffering with isolated STT or TM OA [19,21,22,24]. We believe these approaches offer direct access to the joints without any disruptive dissection of the capsular structures and vascular nourishing vessel. The dorsal TM approach is minimal, it aims to respect the dorso-radial surface of the trapezium where the main vessels are located and therefore avoid any necrosis and consequent trapezium collapse [37]. For us, this dorsal TM approach is relatively comfortable. On the other hand, the volar STT approach aims to respect the dorsal vessels of the scaphoid which nourish its proximal 70–80% and allows to treat any eventual FCR tenosynovitis [38]. The main neurovascular elements at risk during these approaches are the radial nerve for the dorsal TM approach and the palmar carpal branch from the radial artery. In our series, two patients (11%) developed CRPS while in the series treating isolated TM or STT OA no CRPS was observed. This might be explained by this double approach as is it requires more neurovascular dissection than a single approach. However, one of these patients was diagnosed with CRPS before our surgery and the other patient was diagnosed with cervicobrachial neuralgia which are confounders to explain the incidence of CRPS in our series.

One of the strengths of our study is the uniqueness from a monocentric study with a long follow-up. In fact, few other conservative surgeries have been proposed to treat early stages of pantrapezial OA [9,15,16]. Given the biocompatibility and tribological properties of pyrocarbon, number of techniques use this material to treat different stages of trapezial OA. These techniques include interposition implants associated or not to partial or total bone resection and hemiarthroplasties [17,18]. Currently, “Burger arthroplasty” is the first conservative technique indicated for early stages of pantrapezial OA using pyrocarbon. This technique uses a thin implant, bone resection is limited and the soft tissues, capsule and ligament’s attachment are preserved to permit the best cinematic of the scaphoid and metacarpal around the neo-surfaces [19,21]. We believe that the small thickness (1 mm), the biconcave and rectangular shape of this implant offers more stability compared with previous pyrocarbon implants used to treat TM OA which might dislocate more easily and sink into the carpal bones as the bone and the capsuloligamentous structures are less respected during those procedures.

The main limitation of our study is its retrospective design which did not allowed us to collect all the required information necessary to compare pre and postoperative data. With a loss to follow-up of 42%, our results should be analysed critically. In fact, given the advanced age of some patients, their associated conditions, economical and geographical difficulties to assure their follow-up, many of them were not able to return to our clinic and some other refused to return to the last follow-up. However, 94% still had the implant at last follow-up. The development of dorsal intercalated segment instability (DISI) and carpal collapse is one of the evolutions pantrapezial OA or trapeziectomy [6]. This parameter was not measured in our study but in the available x-rays allowing for measurement it does not seem to appear any worsening of the DISI after surgery (Fig. 3). Gauthier et al. have studied the occurrence of worsening of DISI deformity in patients treated with a pyrocarbon implant for STT OA and did not find any difference pre-and postoperatively [19].

Finally, given the mid- and long-terms results of different conservative (“trapezium-sparing”) techniques and the widely

described results of trapeziectomy, it seems that the time to propose randomized clinical trials has arrived. Such high-quality studies should be soon started to solve the unanswered questions about the evolution and best treatment of early pantrapezial OA [28,39,40].

In conclusion, the "Burger arthroplasty" offers good functional and radiological results at medium-term for the treatment of early stages of pantrapezial OA. This low-invasive and trapezium-sparing technique conserves does not burn the bridges to a trapeziectomy in case of an eventual complication or degenerative evolution.

Details of informed consent

All patients gave their informed consent.

Disclosure of interest

P.B. has conflicts of interest with Wright Medical. The other author declares that he has no competing interest.

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Contribution of authors

P.B. designed and supervised the study. C.C. collected the data, analysed the results, wrote and submitted the manuscript.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2021.102979.

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