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Original article

Evaluation of a shape memory staple (Qual[®]) in radial shortening osteotomy in Kienböck's disease: A retrospective study of 30 cases

Évaluation d'une agrafe à mémoire de forme (QUAL[®]) dans l'ostéosynthèse des ostéotomies de raccourcissement du radius dans la maladie de Kienböck : étude rétrospective à propos de 30 cas

J. Laravine^a, T. Loubersac^b, E. Gaisne^b, P. Bellemère^{b,*}

^aCentre des Pathologies Ostéoarticulaires, 95, avenue Raymond Barre, 97430 Le Tampon, Reunion

^bInstitut de la Main Nantes-Atlantique, Santé Atlantique groupe Elsan, boulevard Paul-Gauthier, 44800 Saint-Herblain, France



ARTICLE INFO

Article history:

Received 9 July 2017

Received in revised form 7 February 2019

Accepted 7 February 2019

Available online 22 February 2019

Keywords:

Kienböck's disease

Radial shortening osteotomy

Lichtman's classification

Shape memory staple

Mots clés :

Maladie de Kienböck

Ostéotomie de raccourcissement du radius

Classification de Lichtman

Agrafe à mémoire de forme

ABSTRACT

The QUAL[®] (Memometal, Stryker) device is a shape memory staple used for bone fixation during distal radius shortening osteotomy in the context of Kienböck's disease. The present study is a retrospective, single-center and multisurgeon study of 30 patients with a mean follow-up of 8 years. Clinical criteria (range of motion (ROM), strength, pain and functional score) and radiographic data (ulnar variance, distal radius articular surface inclination, Lichtman stage, carpal height and bone healing) were evaluated pre- and post-operatively. We found satisfactory results with the mean grip strength of 22 kg/F before surgery and 24 kg/F after surgery. The mean ROM was 88° preoperatively and 82° postoperatively and the mean ulnar deviation was 23° preoperatively and 21° post-operatively. There was no change in radial deviation and pronation-supination after surgery. The average ulnar variance was 1 mm before surgery and 0.2 mm after surgery. The inclination of the distal radius articular surface on lateral and anteroposterior views and the mean carpal height were similar to the pre-operative ones. There was no delay in bone healing. The mean pain score was 2 at rest on a visual analogue scale after surgery. Seven patients experienced an increase in their Lichtman stage at the follow-up, and two patients were waiting for conversion to a non-conservative surgical treatment. Seven staples were removed postoperatively. Seventy-eight percent of patients returned to work after 3 months on average. Seventy-five percent of patients were at least satisfied with the outcome of their surgery. The QUAL[®] staple is a reliable option for fixation during shortening osteotomy of the radius in Kienböck's disease.

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R É S U M É

L'agrafe à mémoire de forme QUAL[®] (Memometal, Stryker) est un matériel d'ostéosynthèse des ostéotomies de raccourcissement du radius pour maladie de Kienböck. Cette étude est rétrospective, monocentrique et multi-opérateur comprenant 30 patients avec un recul moyen de 8 ans. Des critères cliniques (amplitudes articulaires, force, douleur et scores fonctionnels Quick DASH et PRWE) et radiologiques (index radio-ulnaire distal RUD, hauteur du carpe, pente radiale dans les plans frontal et sagittal, le score de Lichtman et la consolidation osseuse) ont été évalués en pré- et postopératoire. Les résultats étaient satisfaisants avec une force en moyenne mesurée à 22 kg /F en préopératoire et à 24 kg/F en postopératoire. L'arc de flexion-extension était mesuré en moyenne à 88° en préopératoire et à 82° en postopératoire. L'inclinaison frontale de la surface articulaire distale du radius était évaluée en moyenne à 23° en préopératoire et à 21° en postopératoire. L'inclinaison radiale et la pronation-

* Corresponding author.

supination étaient similaires en pré- et postopératoire. L'index RUD était en moyenne à 1 mm en préopératoire et à 0,2 en postopératoire. L'orientation de la surface articulaire distale du radius dans les plans frontal et sagittal n'avait pas été modifiée par l'intervention. La valeur moyenne de la hauteur du carpe était identique en pré- et postopératoire. La douleur était mesurée à 2 au repos à l'échelle visuelle analogique en postopératoire. Sept patients avaient dégradé leur stade de Lichtman au dernier recul et deux patients étaient en attente d'un traitement chirurgical non conservateur. Sept agrafes ont été enlevées en postopératoire. Soixante-dix-huit pour cent des patients étaient retournés au travail avec un délai moyen de reprise professionnelle à 3 mois. Soixante-quinze pour cent des patients étaient au minimum satisfaits de leur intervention. L'agrafe QUAL[®] est un moyen d'ostéosynthèse fiable dans les ostéotomies de raccourcissement du radius dans le traitement des maladies de Kienböck.

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1. Introduction

Kienböck's disease is an idiopathic avascular necrosis of the lunate. Surgical treatment is recommended from Lichtman stage II in patients who have pain despite conservative treatment. The latter includes 4–6 weeks of immobilization and appropriate analgesics. Radial shortening osteotomy (RSO) is the most common procedure when the ulnar variance is negative or neutral [1]. This surgical technique provides pain management with a mean follow-up of 10 years. However, no studies have demonstrated a halt or deceleration in disease progression [2–7].

When RSO is indicated, each surgeon selects the material to be used, the level of the osteotomy and the surgical approach according to his (her) usual practice. Each option differs due to intraoperative technical difficulties, delay of bone healing, and the occurrence of complications.

The aim of this study was to evaluate the fixation of a distal radius transverse metaphyseal osteotomy by a staple with a “warm” shape memory, namely the QUAL[®] (Stryker-Memo metal, Bruz, France), through the dorsal approach.

2. Material and method

2.1. The QUAL[®] quadrapod staple

The QUAL[®] staple is made of nitinol, a metal alloy (Fig. 1). Metallurgical manufacturing produces a memory shape into nitinol at a certain temperature. The transformation occurs at the atomic level and is reversible as well as instantaneous. For the QUAL[®], a compressive force through its legs can be established by heating the staple to 50 °C. The staple is then used for fixation of RSO. The shape memory results in axial compression at the osteotomy site. This compression induces the fixation stability. The staple is available in two sizes, the QUAL16[®] and the QUAL18[®], differentiated by the length of their legs as 16 mm and 18 mm, respectively. The body of the staple is 2 mm thick, 10 mm wide, and 15 mm long.

2.2. Surgical technique

The procedure is performed under regional anesthesia with a tourniquet at the upper arm. The posterior approach is made through a 5-cm longitudinal incision, between the 3rd and 4th extensor compartments. The osteotomy site is located under fluoroscopy (Fig. 2). The posterior interosseous nerve is resected, and the transverse osteotomy is performed on the metaphyseal part of the radius at the proximal border of the distal radioulnar joint (DRUJ). Two 12/100 K-wires are introduced through the posterior face of the radial epiphysis without crossing the future osteotomy site; this is done to facilitate and maintain reduction of the osteotomy after external compression maneuvers.

The second osteotomy is performed transverse and proximal to the DRUJ (Fig. 3). Thickness of this osteotomy is determined preoperatively by measuring the ulnar variance. Then, the two K-wires are pushed into the anterior cortex of the proximal fragment. External maneuvers are used to close the osteotomy site (Fig. 4). Fluoroscopy is performed to assess reduction and orientation of the distal radius articular surface. When the reduction is perfect, the posterior cortex of the radius is burred at the staple implantation site. By using the provided guide, the location of the staple's legs on the two sides of the osteotomy is chosen with a graduated 2.7 mm drill bit perforating the anterior cortex of the radius. The size of the staple is based on the graduated drill bit. The staple is inserted until bone contact is made and then heated for 1–2 minutes with electric cautery so the legs can be closed (Fig. 5). By using this mechanism, the osteotomy site is compressed. The fixation stability is then verified under fluoroscopy (Fig. 6). The extensor retinaculum is closed. The extensor pollicis longus (EPL) is rerouted dorsally because in most of the cases, Lister's tubercle was removed during bone preparation. A drain is added, and a volar splint used to immobilize the wrist in neutral position for 6 weeks.



Fig. 1. The QUAL[®] quadrapod staple.



Fig. 2. Identification of the osteotomy level under fluoroscopy.

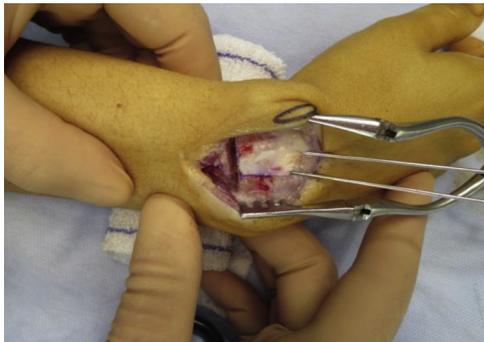


Fig. 3. Epiphyseal-metaphyseal osteotomy at the distal extremity of the radius.



Fig. 4. Compressive external maneuver to close the osteotomy site.

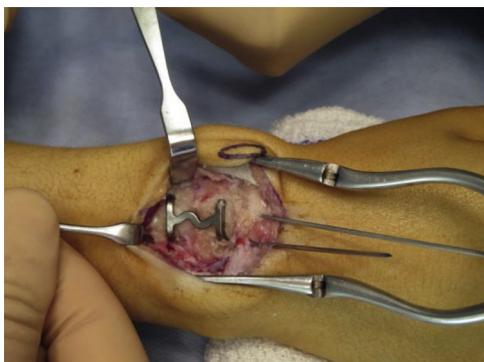


Fig. 5. The QUAL[®] staple after being heated after the posterior cortex has been prepared.

2.3. Methods

This was a retrospective single-center multisurgeon study in which clinical and radiological outcomes were evaluated pre- and postoperatively by an independent examiner (LJ). All the patients were operated at the same facility by three senior surgeons with the technique described above. These patients were contacted by phone and assessed during an office visit between January and July 2013. All the patients underwent an X-ray examination during this visit at the same facility where they were operated at.

They were diagnosed with Kienböck's disease between stage II and IIIB according to Lichtman's classification [8]: three stage II cases, nine stage IIIA cases, and eight stage IIIB cases. Fifteen patients underwent the operation on their dominant hand (14 right-handed and 1 left-handed). In each of the 15 cases, the staple was the QUAL16[®]. Twenty-nine patients had no previous procedures, and no wrists were affected bilaterally. One patient underwent an ulnar shortening osteotomy at another facility 3 years before RSO because of the misdiagnosis of ulnar impingement syndrome. Each patient's wrist was immobilized after surgery with a brace for 6 weeks. Subsequently, patients began functional self-directed rehabilitation without forceful activity for 6 weeks.

Clinical assessment at the review included measurement of range of motion (ROM) in flexion/extension, ulnar and radial deviation, pronation-supination, and strength. Wrist flexion and extension were evaluated with the elbow on a table. Ulnar and radial deviation was measured with the hand prone. Pronation-supination was measured with the elbow in 90° flexion and pressed against the trunk. All these parameters were evaluated with a goniometer. Strength was evaluated in kg/F with a JAMAR[®] hydraulic hand dynamometer (Baseline kit, Arex Palaiseau, France).

Functional scores such as the QuickDASH/100 [9] and PRWE/100 [10], return to work, and postoperative complications were



Fig. 6. Lateral and anteroposterior fluoroscopy views during surgery.

Table 1

Pre- and postoperative mean clinical results for the 30 study patients.

	Pre-operative	Post-operative	Difference	P-value (Wilcoxon test)
Flexion	44	45	+ 1	n.s. ^a
Extension	44	37	- 8	n.s.
Flexion/extension arc	88	83	- 5	n.s.
Ulnar deviation	23	21	- 2	n.s.
Radial deviation	16	16	0	n.s.
Ulnar/radial deviation arc	39	36	- 3	n.s.
Strength (kgF)	22	24	+ 2	n.s.

^a n.s.: not statistically significant.

also recorded. Pain was evaluated with the pain module of the PRWE score divided by 5 for a rating from 0 to 10. Each patient was questioned about his (her) satisfaction with the outcome of the procedure (very satisfied, satisfied, satisfied, not satisfied).

Patients were evaluated with X-rays and CT before surgery and X-rays only at 6 weeks after surgery and at the last review visit. The radiographic criteria included Lichtman staging [8], measurement of ulnar variance [11], carpal height [12], and evaluation of bone healing. Lichtman's stage was determined from X-rays and CT of the operated wrist before surgery and from X-rays after surgery at the last visit by the independent examiner. The distinction between stage IIIa (radioscaphoid angle less than 60°) and stage IIIb (radioscaphoid angle greater than 60°) was made based on a strict lateral X-ray view. Ulnar variance was measured as the distance between a perpendicular line passing through the medial edge of the distal radius articular surface and the parallel tangent to the head of ulna. This was considered negative when it was above -2 mm and neutral when it was between 0 and -2 mm. The carpal height was measured using the Youm and McMurtry index [12]. Bone healing was evaluated on AP and lateral X-rays of the operated wrist and by palpating the osteotomy site 6 weeks postoperatively. The presence of two cortical continuities on each orthogonal plane and the absence of pain at the osteotomy site confirmed bone healing.

Statistical analysis of the pre- and postoperative clinical and radiological results was performed using the Wilcoxon test (P -value < 0.05).

3. Results

3.1. Clinical outcome (Table 1)

Fifty-seven patients benefited from a RSO with the QUAL[®] staple from June 1999 to November 2012. Twenty-seven patients could not be examined: 2 had died, 3 were lost to follow-up, and 22 did not return for the review visit. Thirty patients were included on the study: 11 women and 19 men with a mean age of 41 years (26–70). The mean follow-up of this study was 98 months (13–154) or

8 years. Wrist ROM and grip strength were not modified by surgery on average (P value > 0.05) (Table 2).

Preoperative mean flexion was 44° (20–80), mean extension was 44° (22–70), mean radial deviation was 16° (2–30), and mean ulnar deviation was 23° (0–35). At the last follow-up, mean flexion measured 45° (65°–22°), mean extension measured 37° (10°–60°), the mean radial inclination was 16° (2°–30°) and the mean ulnar deviation was 21° (0°–30°). The mean pronation–supination arc was normal in both cases.

The mean strength was 22 kg/F (8–42) or 60% of that of the contralateral wrist preoperatively, and 24 kg/F (2–32 kg/F) or 63% of the contralateral wrist after surgery. The QuickDASH and PRWE functional scores could not be compared to the pre-operative scores, because only 7 recently operated patients have been evaluated. Post-operatively, for the 30 patients, the mean PRWE Score was 33/100, and the mean QuickDASH score was 23/100.

Pain was 2 (0–9) on average after surgery. Twelve patients (40%) had no pain (0 on PRWE pain module) at rest, 14 (47%) had mild pain (< 5 on PRWE pain module), and 4 (13%) had moderate pain (> 5 on PRWE pain module).

Two patients were retired and were therefore excluded from the work activity assessment. Twenty-four patients returned to their primary occupation; 18 of these were manual workers. Three patients had adjustments in their job descriptions and three others could not return to work due to complications. The mean return to work time postoperatively was 3 months with no complications. It was 9 months after a complication.

The Wilcoxon test showed no statistical difference between pre- and post-operative results.

Twelve patients (40%) were very satisfied after surgery, 10 patients (35%) were satisfied, and six (20%) were moderately satisfied. Two patients were not satisfied by the surgical outcome (5%). One patient was not satisfied because she had to stop playing guitar because of loss of wrist extension. The second patient was not satisfied because he suffered from type 1 complex regional pain syndrome (CRPS1). Table 2 summarizes patient satisfaction according to their ROM, strength, pain and functional scores. We observed no correlation between satisfaction, mobility, strength and Lichtman stage in patients. However, the satisfied and very

Table 2

Comparison between clinical and radiological results with mean satisfaction for the 30 patients at the last follow-up.

Patient satisfaction with outcome	Lichtman stage	Range of motion flexion/ extension/ ulnar deviation/ radial deviation (degrees)	Strength (kgF)	Pain at rest (VAS/10)	Quick-Dash/100	PRWE/100
Excellent 40%	5 stages IIIB 3 stages II	49/48/12 /23	29	3	27	38
Good 35%	1 stage IV 2 stages IIIB 4 stages IIIA	38/35/19/16	27	0.5	28	35
Average 20%	2 stages IIIB 1 stage IIIA 1 stage I	50/38/15/22	9	4	44	56
Poor 5%	1 stage IV	60/40/20/30	14	4	59	57

Table 3

Pre- and postoperative mean radiological results for the 30 study patients.

	Pre-operative	Post-operative	Difference	P-value (Wilcoxon test)
Radial articular surface angle on AP view	10°	10°	0°	n.s. ^a
Radial articular surface angle on lateral view	19°	18°	- 1°	n.s
Carpal height (Youm and McMurtry index)	0.46	0.47	+ 0.01	n.s
Ulnar variance (mm)	+ 1	+ 0.2	- 0.8	0.047
Lichtman stage	3 stage II 9 stage IIIA 8 stage IIIB	3 stage II 6 stage IIIA 9 stage IIIB 2 stage IV	- 3 stage IIIA + 1 stage IIIB + 2 stage IV	

^a n.s.: not statistically significant.

satisfied patients were those who reported experiencing less pain at rest despite restricted range of motion.

3.2. Radiographic outcomes

Preoperatively, the mean distal ulnar variance was equal to 1 mm, and the carpal height was 0.45 [0.33–0.53]. In the frontal plane, the mean distal radius articular surface inclination was 19° [18–24], while in the sagittal plane it was at 10° [0–19] (Table 3).

Postoperatively, the mean ulnar variance was equal to 0.20 mm. The mean carpal height was 0.45 [0.38–0.53] and the distal radius articular surface orientation on the anteroposterior (AP) and lateral views were 19° (11–29) and 10° (0–22), respectively.

Bone healing was achieved after 6 weeks of immobilization in all patients. There were no cases of delayed union or non-union (Fig. 7).

According to Lichtman’s classification, the cohort included three stage II cases, nine stage IIIA cases and eight stage IIIB cases. At the last review visit, there were three stages II cases, six stage

IIIA cases, nine stages IIIB and two stage IV cases. The three stage II cases remained stable. The three stage IIIA cases progressed into stage IIIB, and two stage IIIB cases progressed to stage IV (Table 2). Consequently, the Lichtman stage had deteriorated in five patients (25%).

There was a statistical difference in pre- and post-operative ulnar variance (P value 0.047), but no difference with the other findings.

3.3. Complications

There were no conversions to arthrodesis or partial/total arthroplasty of the wrist. Similarly, no nonunion, tendon rupture or infection occurred during this study.

One case of capitulate osteoarthritis and one case of painful Lichtman stage IV are scheduled for reoperation including lunarectomy and pyrocarbon interposition [13,14].

One patient developed CRPS1. In another case, the staple had moved secondarily, causing malunion of the radius. This patient refused revision surgery. The staple was removed in four patients (13%) because of discomfort at an average of 2 years.

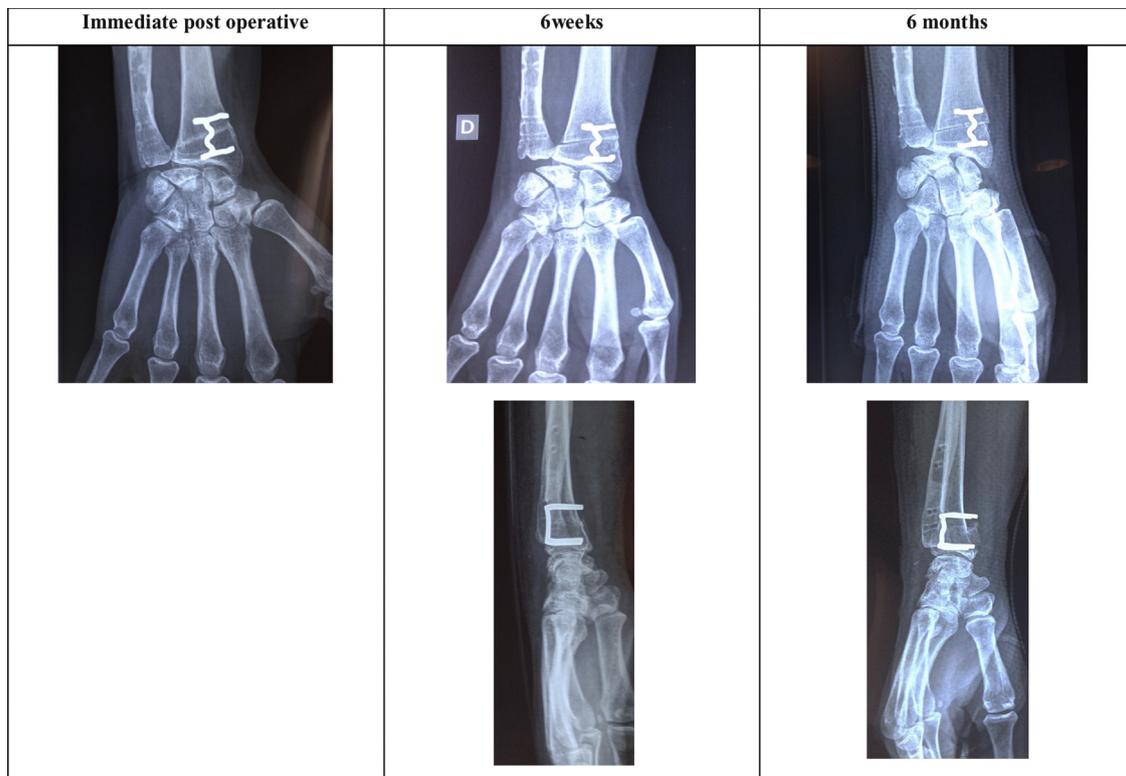


Fig. 7. Anteroposterior and lateral X-rays: immediately postoperative, 6 weeks after the surgery and at 6 months of follow-up.

Table 4
Comparison of our study with other studies of radial shortening osteotomy in Kienböck's disease from 1991 to 2014.

Study	Patients	Mean follow-up (years)	Approach	Fixation method	Osteotomy site	Post-operative clinical results (ROM, Grip in Kg/F (% of contralateral side), Pain at rest)	Post-operative change in Lichtman stage	Complications
Weiss et al. 1991	29	4	anterior	plate	diaphyseal	ROM:106° Grip: 31 Kg/F Pain: 21 none 3 mild 4 none improvement	3% degradation	1 non-union
Gomis et al. 1994	28	5	-	plate/pins/ staples	metaphyseal	ROM: 12% improvement Grip: 41% improvement Pain: 20 none 7 mild 1 moderate	-	-
Garbuio et al. 1996	13	5	6 anterior 7 posterior	plate	metaphyseal	ROM: 10 > (75%), 2 > (50%) Grip: 9 > (75%), 4 > (50%) Pain: -	15 % degradation 7% improvement	1 CRPS type 1 1 fracture after material removal 1 radial nerve irritation 1 delayed union 4 delayed union 2 EPL rupture 2 ulnocarpal impingement 11 material removal including 9 dorsal plates
Desmanet and al. 1996	4	7	posterior	pins	metaphyseal	-	-	-
Quenzer et al. 1997	68	2	anterior posterior	37 T-plate 24 DCP plate 6 pin. 1 screws	diaphyseal epiphyseal	ROM: preserved Grip: 12% improvement Pain: -	-	-
Siala et al. 2000	31	6	anterior	plate	diaphyseal	ROM: 113° Grip: 30% improvement Pain: 20 none 11 moderate	45% improvement 3% degradation	-
Iwasaki et al. 2002	9	3	-	plate	diaphyseal	ROM: 113° Grip: 85% of contralateral side Pain: -	-	-
Koh et al. 2003	25	10	anterior	plate	metaphyseal	ROM: 82% of contralateral side Grip: 85% of contralateral side Pain: 12 none 12 mild 1 moderate	32% degradation 7% improvement	-
Zenzai et al. 2005	14	19	-	plate	diaphyseal	ROM: 165° Grip: 86% of contralateral side Pain: 9 none/4 Mild/ 1 moderate	21% degradation	1 nonunion
Raven et al. 2006	9	16	-	plate	metaphyseal	ROM: 67° Grip: - Pain: 2	22% degradation	-
Altay et al. 2007	23	7	anterior	plate	diaphyseal	ROM: group 1: 102°, group 2: 92° Grip: 44 Pain: 6 none 12 mild 5 moderate	-	-

Table 4 (Continued)

Study	Patients	Mean follow-up (years)	Approach	Fixation method	Osteotomy site	Post-operative clinical results (ROM, Grip in Kg/F (% of contralateral side), Pain at rest)	Post-operative change in Lichtman stage	Complications
Watanabe et al. 2008	13	21	anterior	plate	diaphyseal	ROM: 112° Grip: 28 Kg/F Pain: 7 none 6 Mild	50% degradation	–
Mathoulin and al 2009	22	6	anterior	DCP plate	metaphyseal with vascularized graft	ROM: Improved Pain: 18 none 2 unchanged	–	4 delayed union 1 CRPS 2 repeat surgery
Rodrigues Pinto et al. 2011	18	10	anterior	DCP plate	diaphyseal–metaphyseal	ROM: 100° Grip: 71% Pain: 12 none 16 mild	–	–
Blanco et al. 2012	11	10	posterior	DCP plate	–	ROM: 96° Grip: 38 Kg/F Pain: 6 none / 3 mild/2 moderate	9% degradation	–
Mozaffarian et al. 2012	27	5	anterior	DCP plate	diaphyseal	ROM: negative RUD index: (80%) neutral RUD index: (81%) stage IIIB: (81%) Grip: negative RUD index: (80%) neutral RUD index: (81%) Stage IIIB: (81%) Stage IV: (75%) Pain: 11 none 10 mild 6 moderate	–	–
Afshar et al. 2013	12	6	posterior	DCP plate	–	ROM: 156° Grip: 38 Kg/F Pain: 6 none 3 mild 2 moderate	–	–
Viljakka et al. 2013	16	25	posterior	13 plate + 3 Pins	–	ROM: 101° Grip: (54%) Pain: 12 none	25% degradation 6% improvement	2 fractures after material removal 1 nonunion
Matsui et al. 2014	11	14	anterior	plate	diaphyseal	ROM: 126° Grip: (90%) Pain: 5 none 6 mild	–	–
Our Study	30	8	posterior	staple	epiphyseal	ROM: (83°) Grip: 24 Kg/F Pain: 2	24% degradation	1 malunion 7 material removal 1 CRPS type 1 2 scheduled intracarpal fusion or pyrocarbon implant

EPL: extensor pollicis longus; ROM: range of motion; CRPS: complex regional pain syndrome.

4. Discussion

Fixation of a metaphyseal RSO with the QUAL[®] memory staple through the dorsal approach is a new technical option in the treatment of Kienböck's disease.

We found two complications with this simple technique: one case of secondary displacement of the staple causing radius malunion and one case of CRPS1. The secondary displacement can be explained by the absence of deformation of the staple legs and therefore osteotomy compression at the time it was heated. Indeed, this patient did not have delayed union after the procedure. Sixteen patients (80%) returned to their work activities an average of 3.4 months after surgery. ROM, strength, and radiological criteria were similar pre- and postoperatively, with 40% of patients being pain-free at rest. Following this procedure, 75% of patients were at least satisfied with the surgical outcome. These results are not surprising because they are similar to those reported in the literature (Table 4). Nevertheless, every author used different surgical techniques in terms of the approach, level of the osteotomy, fixation hardware, and inclusion of stages IIIB or not.

Bone fixation is often done with a locking compression plate through an anterior approach [3–6,15–20]. The use of a posterior approach is rare [7,21–24]. Osteotomy is mainly diaphyseal [5,6,16,17,19,20,25] and rarely metaphyseal [3,7,15,18,23,26]. Quenzer et al. [25] are the only surgeons who performed an epiphyseal osteotomy with plate fixation, but the approach remains unclear. Plate fixation allows rapid mobilization of the wrist because of stable fixation but is technically more demanding. On the one hand, when it is performed through an anterior approach, there is a higher risk of injury to the neurovascular structures and flexor tendons. On the other hand, once the osteotomy has been performed, the distal fragment becomes unstable similar to that after an extra-articular fracture, requiring external maneuvers to properly reduce the osteotomy then secure it. In our study, RSO is performed through the dorsal approach which allows direct access to the epiphysis. This reduces the risk of nerve or tendon lesions [27,28].

Four staples (13%) were removed because of discomfort. This sensation disappeared with the application of an abrasive cutter to the posterior cortex of the radius. There were no cases of tendon rupture or recurring fracture after the material had been removed, as reported by Gomis et al. [23], Quenzer et al. [25], Garbuio et al. [26], Watanabe et al. [5] and Viljakka et al. [24]. Moreover, we observed no delayed union or nonunion as observed by Desmanet [29], Mathoulin and Wahegaonkar [15] Quenzer et al. [25], Altay et al. [17], Watanabe et al. [5], Weiss et al. [20] and Viljakka et al. [24]; this is because this osteotomy is performed in a richly vascularized site. When the osteotomy is made at the distal radius and plate fixation is used, the risk of flexor tendon rupture increases when the watershed line is exceeded. Numerous studies demonstrated the benefit of hardware removal to limit this risk in such cases [30–32].

Messina [33] and Desmanet [29] used pins for fixation of RSO in Kienböck's disease. These were extra-focal [33] or intramedullary [29] pins used with a modified Py procedure using the dorsal approach. The procedure is simple but less stable than a plate and requires subsequent removal when bone healing is acquired.

The use of a staple in RSO in the literature is very rare. Gomis et al. [23] and Camus and Van Overstraeten [34] provided some examples of bipodal staples.

Contrary to some studies, our criteria for choosing an RSO differ from traditional surgical practices. In fact, Lichtman stage IIIB is no longer an indication for RSO for some authors [35,36]. Altay et al. [17] and Iwasaki et al. [37] had the same indications as us and did not find radiological degradation for these stages. In our study, 25% of stage IIIB cases progressed to stage IV after surgery and overall, the Lichtman stage degraded in 20% of the included patients. Our

study demonstrates that the QUAL[®] staple provides strong fixation with reliable compression of an metaphyseal RSO without affecting the tendon extensor.

The main weakness of this study is the lack of comparison with non-operated patients with Kienböck's disease or another kind of fixation. The second weakness is the small number of patients. This does not allow for a robust statistical analysis.

5. Conclusion

Fixation of a metaphyseal RSO by the QUAL[®] memory shape staple is a simple, reliable technique. This technique allows distal osteotomy at the DRUJ. Fixation of the osteotomy site with the staple was strong enough to achieve fusion in all cases. This minimally invasive technique is reliable enough to be used for the radius shortening indicated for treating Kienböck's disease.

Disclosure of interest

P. Bellemère has a conflict of interest to disclose with Stryker. The other authors declare that they have no competing interest.

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