Orthopaedics & Traumatology: Surgery & Research 105 (2019) 1617–1625

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Review article

Contribution of arthroscopy to the management of intra-articular distal radius fractures: Knowledge update based on a systematic 10-year literature review

Marc Saab[a,*], Elvire Guerre[a], Christophe Chantelot[a], Philippe Clavert[b], Matthieu Ehlinger[c], Thomas Bauer[d], the SoFCOT[e]

[a] Service orthopédie B, hôpital Roger-Salengro, CHRU de Lille, rue du Professeur-Emile-Laine, 59037 Lille cedex, France
[b] Service de chirurgie du membre supérieur, CCOM, Hôpitaux Universitaires de Strasbourg, avenue Baumann, Illkirch cedex, France
[c] Service de chirurgie orthopédique et de traumatologie, Hôpital de Hautepierre, Hôpitaux Universitaires de Strasbourg, 1, avenue Molière, 67098 Strasbourg cedex, France
[d] Service de chirurgie orthopédique et traumatologie, Hôpital Ambroise Paré AP-HP, 9, avenue Charles-de-Gaulle, 92100 Boulogne-Billancourt, France
[e] 56, rue Boissonade, 75014 Paris cedex, France

ARTICLE INFO

Article history:
Received 26 August 2018
Accepted 19 June 2019

Keywords:
Wrist arthroscopy
Intra-articular distal radius fracture
Triangular fibrocartilage complex
Scapholunate ligament
Carpal ligaments

ABSTRACT

The objective of this study was to review current data on the contribution of wrist arthroscopy to the management of intra-articular distal radius fractures (IADRFs). The literature published over the last 10 years was reviewed by searching databases with the key indexing terms 'distal radius fracture', 'articular', and 'wrist arthroscopy'. The information in the 21 articles thus retrieved was used to answer the following questions: (i) Can arthroscopy improve the reduction of IADRFs? (ii) How does arthroscopy contribute to the diagnosis and treatment of concomitant ligament injuries? and (iii) Does arthroscopy help to improve the functional scores? The contribution of arthroscopy to IADRF reduction remains controversial. Follow-ups were limited (15 months on average) and some of the studies provided only level IV evidence. The data do not consistently suggest that arthroscopically assisted surgery may improve the quality of reduction. In contrast, they highlight the usefulness of arthroscopy in allowing the same-stage management of carpal ligament injuries. In the 12 studies providing data on this point, scapholunate inter-osseous ligament injuries were present in 41% of cases; one-fourth of these injuries were full-thickness tears that were successfully repaired by arthroscopy. The triangular fibrocartilage complex was injured in 48% of cases, and 30% of these injuries were peripheral ulnar detachments that were successfully repaired by arthroscopy. At present, arthroscopy does not allow the repair of all diagnosed ligament injuries. Comparative studies with longer follow-ups will shed light on the ability of arthroscopy to improve functional scores.
Level of evidence: IV.

1. Introduction

The publication over the last decade of numerous studies assessing the contribution of arthroscopy to the management of intra-articular distal radius fractures (IADRFs) bears witness to the fast pace of development of wrist arthroscopy. These studies focused on two main points, namely, achieving anatomical reduction to restore the joint surface and managing any concomitant ligament injuries.

The objective of this study was to review current data on the contribution of wrist arthroscopy to the management of IADRFs. To this end, the literature published over the last decade was reviewed to seek answers to the following questions:

- can arthroscopy improve the reduction of IADRFs?;
- how does arthroscopy contribute to the diagnosis and treatment of concomitant ligament injuries?;
- does arthroscopy help to improve the functional scores?

* Corresponding author.
E-mail address: marc.saab@outlook.com (M. Saab).

https://doi.org/10.1016/j.otsr.2019.06.016
1877-0568/

2. Material and methods

A systematic literature review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline [1].

2.1. Literature search strategy

The PubMed, Ovid, and Cochrane databases were searched for articles published between 1 January 2006 and 1 November 2017, using the key indexing terms 'distal radius fracture', 'articular', and 'wrist arthroscopy'.

2.2. Article eligibility criteria

Articles were potentially eligible if they compared internal IADRF fixation and/or the diagnosis and treatment of acute carpal injuries with versus without arthroscopic assistance or if they were case-series studies of patients managed with arthroscopic assistance. Only studies of adult patients were included. Fracture displacement and inter-fragmentary gap had to be among the criteria used to assess improvements in IADRF reduction. The diagnosis and treatment of carpal injuries had to be described. Finally, outcomes had to be reported based on the functional scores used for wrist surgery (range of motion, grip strength, visual analogue scale [VAS] scores, Disabilities of the Arm, Shoulder, and Hand [DASH] score, Mayo Wrist score, and/or Patient-Rated Wrist Evaluation [PRWE]).

The following article types were excluded: literature reviews, biomechanical and anatomical studies, technical notes, letters to editors, continuing medical education articles, and articles in languages other than French or English.

2.3. Article selection

The above-described inclusion criteria were assessed by reading the titles and abstracts or, if these were not available, the full-length article. Each abstract was read by two observers after the elimination of duplicates. Disagreements about eligibility for inclusion in the literature review were resolved by a third person. Selected articles were read in their entirety.

2.4. Data extraction

For each selected article, the data were categorised as follows: information on the authors; year of publication; study design; level of the evidence supplied by the study; number of patients; diagnostic and therapeutic methods that were used or compared; diagnosis and management of concomitant carpal injuries; assessment criteria, with the results; follow-up duration; and clinical and radiological outcomes at last follow-up.

2.5. Study quality assessment

The methodological quality of the selected studies was evaluated by two observers, who used the modified rating scale developed by Downs and Black for randomised and non-randomised studies (1998) [2]. Disagreements were resolved by discussion between the two observers or with a third observer. The Downs and Black rating scale has 27 items in 5 sections (reporting, external validity, internal validity - bias, internal validity–confounding, and power).

3. Results

3.1. Database search and article analysis and selection

Fig. 1 is the search flow diagram. The search of the three databases retrieved 491 articles. After the elimination of duplicates, 131 articles were selected based on the abstract. Among them, 21 met the article selection criteria and were assessed in their entirety.

The review sought to answer three questions:

- can arthroscopy improve the reduction of IADRFs?;
- how does arthroscopy contribute to the diagnosis and treatment of concomitant ligament injuries?;
- does arthroscopy help to improve the functional scores at last follow-up?

3.2. Can arthroscopy improve the reduction of intra-articular distal radius fractures (IADRFs)?

Of the 21 articles, 16 were used to answer this question, with a total of 720 patients, a mean of 45 patients per article, and a mean follow-up of 15 months. Of the 16 studies, 11 were case series, 4 were prospective [3–6], and 1 was retrospective [7]. The quality of reduction was compared using computed tomography (CT) measurements in 2 studies [5,7], whereas the other studies relied on radiographic parameters [3,4,6,8], arthroscopic findings [9–13], or both [14–17].

The system used to classify the fractures varied across studies, with the AO classification [18] being used most often and the classifications devised by Frikman [8,19] and Castaing [9] less often. The internal fixation methods varied also. Pinning was used alone in some studies [3,9] and combined with external fixation in others [4,8]. Several studies used an anterior locking plate [5,6,10,12,13,15–17] or several different fixation methods depending on the type of fracture [19,11,7]. In studies comparing two groups, the contribution of arthroscopy was chiefly assessed based on step-off and inter-fragmentary gap [3–7]. These same criteria were also used in non-comparative studies. In 1 study, step-off was evaluated according to the Knirk and Jupiter grade [8]. Of the 16 studies, 13 indicated a beneficial effect of arthroscopy for IADRF reduction. A beneficial effect was defined in comparative studies as statistically significant improvements in the assessment criteria compared to the group without arthroscopy and in non-comparative studies as improvements in step-off and inter-fragmentary gap with the use of arthroscopy. Table 1 recapitulates the main findings from these studies.

3.3. How does arthroscopy contribute to the diagnosis and treatment of concomitant ligament injuries?

Of the 21 studies published over the 10-year period, 12 provided information on this point, with a total of 467 patients and a mean follow-up of 22 months. Two studies report data from the same cohort of patients followed up for at least 13 years [20,21]. In 9 other studies, follow-up was 1 year or less [7–9,17,22–26]. Of the 12 studies, 2 were comparative [4,7] and 10 non-comparative. The assessment criteria in these studies were the proportions of patients diagnosed with injuries to the scapholunate interosseous ligament (SLIL) and/or triangular fibrocartilage complex (TFCC). The methods used to treat these injuries in the non-comparative studies were described. Some studies also analysed clinical assessment criteria [9,20–22,25,26]. Arthroscopy was deemed beneficial when its use enabled the diagnosis and/or treatment of carpal injuries or when failure to treat carpal injuries resulted in poorer clinical and radiological outcomes [22,25]. Arthroscopy was considered

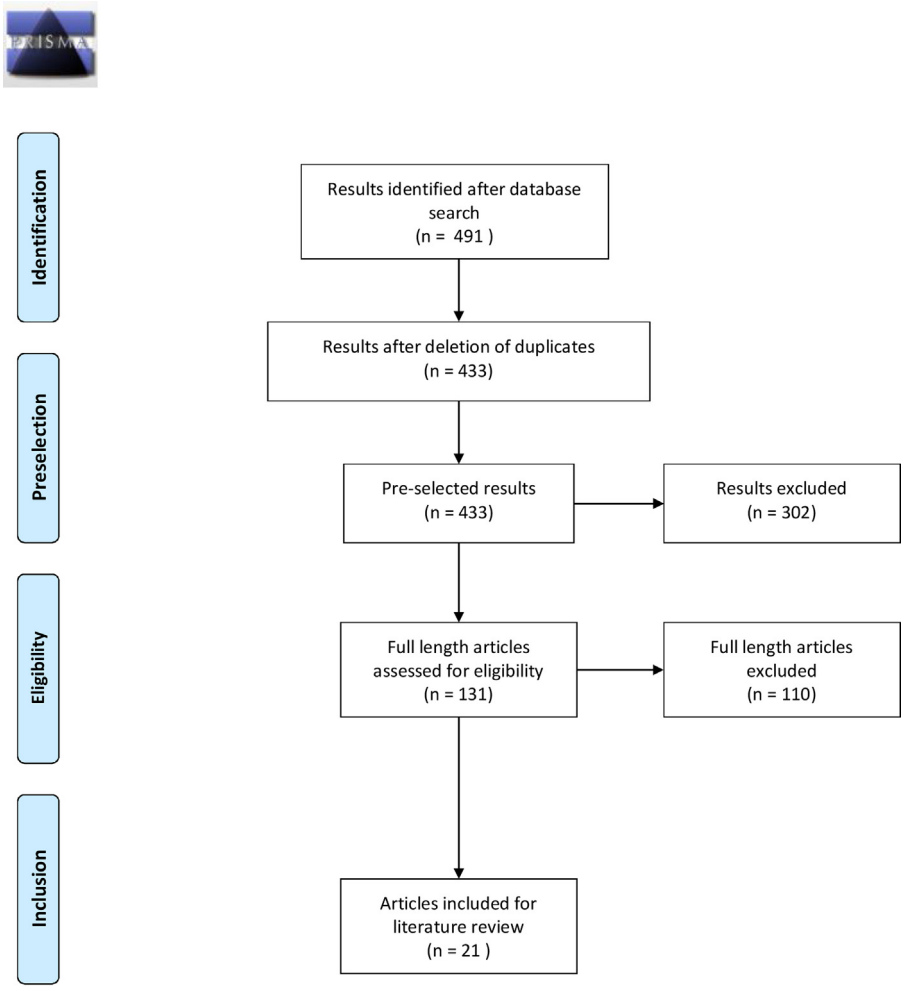

Fig. 1. PRISMA 2009 Flow Diagram.

unhelpful when the diagnosis and/or treatment of concomitant carpal injuries failed to improve patient outcomes.

Arthroscopy provided the diagnosis of SLIL injuries in 41% of cases with a total of 189 lesions. SLIL injuries were classified according to Geissler [27] in all but 1 study, which used the European Wrist Arthroscopy Society (EWAS) classification [28]. Of the 189 lesions, 144 (76.2%) were Geissler grade I or II (partial injuries) and 45 (23.8%) were Geissler grade III or IV (complete injuries). SLIL tears were managed by scapholunate pinning [7,8,25,26]. In some studies, diagnosed SLIL injuries were left untreated [9,20,22], whereas in others pinning was performed routinely in patients with diagnosed injuries, with no concomitant arthroscopic procedure [4,11,23]. In 1 study, grade IV injuries were managed by open repair [24].

Arthroscopy showed TFCC injuries in 48.46% of cases. The 147 lesions were classified according to Palmer [29], which showed the following distribution: Class 1A, $n = 45$ (30.6%); Class 1B, $n = 45$ (30.6%); Class 1 C, $n = 18$ (12.2%); and Class 1D, $n = 36$ (24.5%); 3 injuries were not classified. In several studies, diagnosed TFCC injuries were left untreated [8,9,21,22]. Class 1B injuries were repaired by arthroscopic suture in all but 1 study [4], which used open repair. Other lesion types were generally managed by arthroscopic debridement [4,7,11,23,24], although splinting was used in 1 study for type 1D injuries [24].

In 8 studies, the results supported a positive contribution of arthroscopy to the diagnosis and treatment of carpal injuries concomitant to IADRFs [4,7,8,11,22–25].

Table 2 lists the data from the selected studies and the main conclusions.

3.4. Does arthroscopy help to improve the functional scores at last follow-up?

The 12 studies that assessed functional scores at last follow-up had a total of 552 patients with a mean follow-up of 30.3 months, although follow-up was 12 months or less in half the studies [6,8,9,13,17,26]. Three studies used a prospective comparative design [3,4,6]. The most often used functional parameters were the MWS, DASH, a VAS score, and range of motion. Grip strength was measured in several studies [3,4,6,10,12,13,20,21] and the PRWE score in 1 study [12]. Finally, the development of radio-carpal osteoarthritis was evaluated in 2 studies including 1 with a long follow-up [8,20,30].

Of the 12 studies, 6 supported a beneficial effect of arthroscopy in improving the functional scores at last follow-up [3,4,8,10,12,13]. A case-series study was inconclusive [11] and the 5 remaining studies were not in favour of arthroscopy [6,9,17,26].

Table 3 reports the main data on functional scores at last follow-up.

3.5. Methodological quality of the selected studies

Table 4 reports the results of the Downs and Black evaluation of study quality. The methodological score ranged from 11/27 to

Table 1
Main data on quality of articular surface restoration.

Year/Study	Patients (Ascp)	Level of evidence	Treatment	Mean follow-up, months	Outcomes	Conclusion	Favourable to Ascp, yes or no
2006 Hardy et al.	18 (18)	IV	IF with Ascp assistance	12	Mayo Wrist Score decreased with increasing Knirk-Jupiter (step-off) grade	Articular surface restoration is the most important prognostic criterion.	Yes
2007 Battistella et al.	80 (40)	II	IF with versus No Ascp assistance	38	With Ascp, better coronal inclination, ulnar variance, and joint surface restoration	IF with Ascp assistance is better than the conventional method.	Yes
2007 Hattori et al.	28 (28)	IV	IF with Ascp assistance and volar plate or external fixation in patients > 70 years	24.9	Mayo Wrist Score 80.1 ± 0.5 23 returned to previous activities	Ascp assistance is an effective option in older, physically active patients	Yes
2008 Varitimidis et al.	40 (20)	II	IF with versus No Ascp assistance	24	After 24 months, smaller step-off with vs. without Ascp (0.3 vs. 0.8, $P < 0.01$)	Ascp assistance improves articular surface restoration	Yes
2008 Lutsky et al.	16 (16)	IV	Ascp and Fscp to guide reduction compared using a subjective VAS	0	Fscp: 8.2/10 Ascp: 6.4/10	Fscp assessment underestimates residual displacement	Yes
2010 Ono et al.	31 (31)	IV	Ascp to assess step-off and inter-fragment gap after IF with volar locking plate	0	7 patients with displacement $\geq$2 mm	Ascp assistance if pre-operative displacement $\geq$5.80 mm	Yes
2011 Levy et al.	35 (35)	IV	IF with Ascp assessment after 6 weeks	12	Only 9 patients with inter-fragment gap > 1 mm and 2 with step-off > 1 mm	Reserve Ascp assistance for young patients	No
2012 Ono et al.	70 (70)	IV	Ascp to assess step-off and inter-fragment gap after IF with volar locking plate	13	15 patients with step-off $\geq$ 1 mm 40 patients with inter-fragment gap $\geq$ 1 mm	Ascp helpful when the pre-operative sup of step-off and inter-fragment gap is >7.85 mm	Yes
2013 Abe et al.	153 (153)	IV	IF with Ascp assistance and plate pre-setting arthroscopic reduction technique (PART)	30	35.2% of patients with displacement corrected with Ascp assistance	Plate pre-setting and Ascp assistance provide effective reduction and decrease surgery invasiveness.	Yes
2013 Burnier et al.	40 (20)	II	IF CT after 3 months to compare step-off and inter-fragment gap with vs. without Ascp	3	No Ascp: step-off reduction not significant ($P > 0.05$) With Ascp: significant step-off reduction ($P < 0.05$)	Ascp assistance improves articular surface restoration	Yes
2013 Khanchandani et al.	27 (27)	IV	IF with Ascp assistance	26	In 5 patients intra-operative IF modification after Ascp evaluation	Ascp assessment allows correction of residual step-off	Yes
2014 Del Piñal et al.	4 (4)	IV	IF of comminuted diaphyseal-metaphyseal fractures with Ascp assistance	36	Step-off < 1 mm in 4 patients	Ascp assistance allows the reduction of intra-articular fractures with diaphyseal-metaphyseal comminution	Yes
2014 Zemirline et al.	20 (20)	IV	IF via a 15-mm anterior approach, with Ascp assistance	4	19 patients with step-off < 1 mm	Inconspicuous scar, anatomical reduction, diagnosis and treatment of concomitant ligament injuries	Yes
2015 Yamazaki et al.	74 (37)	II	IF with versus No Ascp assistance	11	No significant difference in step-off or inter-fragment gap between the 2 groups after 6 or 48 weeks	Ascp assistance does not improve articular surface restoration	No
2016 Thiart et al.	44 (44)	IV	IF under Fscp guidance then intra-operative Ascp assessment	3	Step-off: 0 mm (33 patients) 0-1 mm (3 patients) 1-2 mm (8 patients) Inter-fragment gap: 0 mm (37 patients) 0-2 mm (6 patients) 3 mm (1 patient)	Ascp showed acceptable step-off and inter-fragment gap with Fscp assistance. Limited role for Ascp assistance in reducing intra-articular fractures	No
2017 Christiaens et al.	40 (20)	III	IF with vs. without Ascp assistance	3	After 3 months, smaller step-off in the Ascp group	Ascp improves the reduction of IADRFs	Yes
	720			15			

Ascp: arthroscopy; IF: internal fixation; Fscp: fluoroscopy; VAS: visual analogue scale; CT: computed tomography; IADRF: intra-articular distal radius fracture.

Table 2
Main data on the diagnosis and treatment of carpal injuries concomitant to intra-articular distal radius fractures.

Year/Study	Patients (Ascp)	Mean FU (mo)	SLIL (%)	Geissler grade				TFCC (%)	Palmer				Treatment		Conclusion	Favourable to Ascp, yes or no
				1	2	3	4		1A	1B	1C	1D	SLIL	TFCC		
2006 Hardy et al.	18 (18)	12	28	4 'partial'		1 'complete'		17			1	2	SLIL pinning in 2 patients	None	Ascp allows the treatment of concomitant injuries	Yes
2007 Forward et al.	51 (51)	12	86	11	23	10							None	None	After 12 months, significant increase in the SL angle, SL pain and instability if Geissler 3	Yes
2008 Varitimidis et al.	40(20)	24	45		7	2		60		6		6	SLIL pinning in 9 patients	Debridement of all lesions with Ascp repair in 1 case and open repair in 1 case	The treatment of concomitant lesions may have contributed to the better scores in the Ascp group	Yes
2011 Levy et al.[a]	35 (35)	12	28	3 grade 1 or 2		7 EWAS grade 3,4 or 5		28		3*			None	None	No correlation between anatomical ligament injuries and functional scores after 1 year	No
2013 Araf et al.	30 (30)	0	36.6	2	6	2	1	76.7	4	7	14	2	Repair of all identified lesions		High incidence of carpal lesions in IADRFs	Yes
2013 Ogawa et al.	85(85)	0	54.5	39		6	3	40	27	2		5	Grade 1-2: none; grade 3: SLIL pinning; grade 4: open repair	1A: debridement, 1B Ascp suture, 1D BABP	Haute incidence of carpal injuries, independently from the fracture	Yes
2013 Khanchandani et al.	27 (27)	26	29	3	2	1	2	62		15		2	Grades 2-3-4: SLIL pinning 8 weeks	1B suture if large lesion, debridement for 1D and small 1B lesions	Ascp contributes to the diagnosis and treatment of concomitant injuries.	Yes
2012-2015 Mrkonjic et al.	38 (38)	156	68.4	17 grade 1-2	9			86.8	7	7	2	9	None	None	SLIL injuries grades 1-3 and TFCC injuries do not influence the objective or subjective functional scores or the radiographic outcomes after a minimum follow-up of 13 years	No
2015 Kasapinova et al.	40 (40)	6	35	2	5	5	2						Grade 3-4: SLIL pinning		Lower functional scores at 3 and 6 months if SLIL injury Ascp useful for managing these lesions	Yes
2016 Thiart et al.	44 (44)	3	6.8	15				34.1					None	Repair of a single TFCC lesion	Haute incidence of carpal lesions in patients with IADRFs	No
2017 Swart et al.	42 (42)	12	45	11	7	1		50	7	6		8	Grade 3: SLIL pinning	Debridement	No difference in functional scores at 12 months between groups with vs. without SLIL and/or TFCC injuries	No
2017 Christiaens et al.	40 (20)	3	30	3	1	2		30		2	1	2	Grade 3: SLIL pinning	1B Ascp suture, debridement for 1 C and 1D	Ascp allows the management of these lesions.	Yes
	467	22,16667	41.0 (25)					48.46								
				Partial lesions (grade 1 or 2): 144/189 (76.2%)	Complete lesions (> grade 3): 45/189 (23.8%)				45/147 (30.6%)	45/147 (30.6%)	18/147 (12.2%)	36/147 (24,5%)				

FU:follow-up; mo:months; SLIL:scapho-lunate inter-osseous ligament; TFCC:triangular fibrocartilage complex; SL:scapholunate; IADRF:intra-articular distal radial fracture.
[a] 1B, C, or D (not specified).

Table 3
Main data on the functional scores at last follow-up.

Year/Study	Patients	Type	Outcome measures	Mean FU (mo)	Outcomes	Conclusion	Favourable to Ascp, yes or no
2006 Hardy et al.	18	IV	Mayo Wrist Score	12	Mayo Wrist Score decreases as Knirk-Jupiter grade (step-off) increases	Articular surface restoration is the most important prognostic criterion	Yes
2007 Battistella et al.	80	II	ROM, grip, VAS, DASH	38	Ascp group: better functional scores, greater motion range, greater grip strength ($P < 0.05$)	IF with Ascp assistance is better than the conventional method.	Yes
2008 Varitimidis et al.	40	II	ROM, grip, DASH, Mayo Wrist Score at 12 and 24 months	24	After 12 and 24 months: Mayo Wrist Score better in the Ascp group, DASH not significantly different At 12 months: flexion-extension, and supination better in the Ascp group	Functional scores and ROM better with Ascp	Yes
2011 Levy et al.	35	IV	ROM, DASH	12	Mean DASH 34.9 ± 21 VAS: 3	No correlation between anatomical reduction and functional scores	No
2013 Abe et al.	145	IV	ROM, grip, Mayo Wrist Score, DASH	30	Mean DASH: 4.1 Mayo: 112 excellent, 31 good, 2 fair	Plate pre-setting and Ascp assistance provide effective reduction and decrease surgery invasiveness	Yes
2013 Khan-chandani et al.	27	IV	Mayo Wrist Score	26	20 excellent, 3 good, 4 fair	No conclusion regarding the clinical score	
2014 Del Piñal et al.	4	IV	ROM, grip, VAS, DASH, PRWE	36	Mean PRWE: 9 mean DASH: 10 Flexion 70% Extension 90% Grip 95% (vs. normal side)	Clinical outcomes similar to those in other studies	Yes
2014 Zemirline et al.	17	IV	ROM, Quick DASH, grip, VAS	4	VAS 1.9 (0-7) Quick DASH 24.6 (0-70) ROM vs. normal side, 71% to 86% Grip 67% of normal side	Inconspicuous scar, longer follow-up required	Yes
2015 Mrkonjic et al.	38	IV	DASH, VAS, grip, Gartland and Werley, osteoarthritis (if SLIL injury)	156	None of the subjective or objective criteria differed significantly between peripheral partial or central vs. complete TFCC injury or between SLIL injury grade 0-1-2 vs. 3	Grade 1-3 SLIL injuries and TFCC injuries do not influence the subjective or objective scores or the radiographic outcomes after a minimum of 13 years.	
2015 Yamazaki et al.	74	II	ROM, grip, DASH	11	DASH, grip, ROM: no significant difference between groups	Functional scores at last follow-up not better with Ascp	No
2016 Thiart et al.	44	IV	ROM	3	flexion 41 ± 10° extension 51 ± 17 pronation 85 ± 5° supination 74 ± 20°	Good outcomes but longer-term data on functional scores needed	No
2017 Swart et al.	30	IV	DASH, VAS, ROM	12	DASH, VAS, ROM: no significant differences	No difference in functional scores at 12 months between the groups with vs. without SLIL and/or TFCC injuries	No
	552			30.3			

Ascp: arthroscopy; ROM: range of motion; VAS: visual analogue scale; PRWE: patient-rated wrist evaluation; SLIL: scapholunate interosseous ligament; TFCC: triangular fibrocartilage complex; FU: follow-up; mo: months.

24/27. External validity was usually good. In contrast, most studies used a non-comparative design and therefore had limited internal validity. The objectives were stated clearly and the evaluation criteria were well defined. Statistical power was estimated in a single study, which had the highest methodological score.

4. Discussion

The objective of this literature review was to clarify the contribution of arthroscopy to the management of IADRFs by obtaining answers to three questions.

4.1. Can arthroscopy improve the reduction of intra-articular distal radius fractures (IADRFs)?

The available data leave room for controversy regarding the contribution of wrist arthroscopy to the reduction of IADRFs. Many studies used a case-series design and were therefore unable to demonstrate that arthroscopic assistance was superior over internal fixation with fluoroscopic guidance alone. In addition, most studies had small sample sizes, with a mean of 45 patients per study.

The data were conflicting even for the subgroup of prospective studies [4–7]. The differences across studies in the internal fixation methods used hinder comparisons of outcomes. A randomised trial by Varitimidis et al. [4] compared the quality of articular restoration with fluoroscopy versus arthroscopy in 40 patients managed for IADRFs between July 2000 and October 2003. In one group, reduction was assisted by fluoroscopy alone and maintained by external fixation and percutaneous pinning; a minimally invasive dorsal approach to the wrist was performed if the reduction was deemed unsatisfactory. The other group was managed in the same way but with added arthroscopic assistance. The external fixator was removed after 6 weeks in both groups. The residual step-off

Table 4
Methodological quality of the studies.

Year/Study	Level of evidence	Reporting 10	External validity 3	Internal validity - bias 7	Internal validity–Confounding 6	Power 1	Total
2006 Hardy et al.	IV	1/1/1/0/1/1/0/1/1/0 = 7	0/0/1 = 1	0/0/1/0/0/1/1 = 3	1/1/0/0/0/1 = 3	0	14
2007 Battistella et al.	II	1/1/1/1/1/1/0/1/1/0 = 8	1/1/1 =3	0/0/0/1/1/1/1 = 4	1/0/0/0/1/0 = 2	0	17
2007 Hattori et al.	IV	1/1/1/1/0/1/1/0/1/0 = 7	0/0/1 = 1	0/0/0/1/0/1/1 = 3	1/1/0/0/0/1 = 3	0	14
2008 Varitimidis et al.	II	1/1/1/1/2/1/1/1/1/1 = 10	1/1/1 =3	0/0/0/1/1/1/1 = 4	1/1/1/0/1/1 = 5	0	22
2008 Lutsky et al.	IV	1/1/1/1/0/1/0/0/0/0 = 5	1/1/1 = 3	0/0/0/0/1/1/0 = 2	1/0/0/0/0/0 = 1	0	11
2010 Ono et al.	IV	1/1/1/1/1/1/1/0/1/1 = 9	1/1/1 = 3	0/0/1/1/1/1/0 = 4	1/1/0/0/0/1 =3	0	19
2011 Levy et al.	IV	1/1/1/1/1/1/1/1/1/1 = 9	1/1/1 =3	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	20
2012 Ono et al.	IV	1/1/1/1/1/1/1/0/1/1 = 9	1/1/1 = 3	0/0/1/1/1/1/0 = 4	1/1/0/0/0/1 = 3	0	19
2013 Abe et al.	IV	1/1/1/1/1/1/0/0/1/0 = 7	1/1/1 =3	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	18
2013 Burnier et al.	II	1/1/1/1/1/1/0/0/1/0 = 7	1/1/1 = 3	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	18
2013 Khanchandani et al.	IV	1/1/1/1/0/1/0/1/1/0 = 7	1/1/1 = 3	0/0/1/0/0/1/1 = 3	1/1/0/0/0/1 = 3	0	16
2014 Del Piñal et al.	IV	1/1/1/1/0/1/0/1/1/0 =7	0/0/1 = 1	0/0/1/0/0/1/1 = 3	1/1/0/0/0/1 = 3	0	14
2014 Zemirline et al.	IV	1/1/1/1/1/1/0/1/1/0 = 8	1/1/1 = 3	0/0/1/0/0/1/1 = 3	1/1/0/0/1/1 = 4	0	18
2015 Yamazaki et al.	II	1/1/1/1/1/1/1/1/1/1 = 9	1/1/1 = 3	1/0/0/1/1/1/1/1 = 6	1/1/0/1/1/1 = 5	1	24
2016 Thiart et al.	IV	1/1/1/1/1/1/0/0/1/0 = 7	1/1/1 = 3	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	18
2017 Christiaens et al.	III	1/1/1/1/1/1/1/1/1/1 = 9	1/1/1 = 3	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	20
2007 Forward et al.	IV	1/1/1/1/0/1/0/1/1/1 = 8	1/1/1 = 3	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	19
2013 Araf et al.	IV	1/1/1/1/1/1/1/0/1/1 = 9	0/1/1 = 2	0/0/1/0/1/1/1 = 4	1/1/0/0/0/1 = 3	0	18
2013 Ogawa et al.	IV	1/1/1/1/1/1/0/0/1/1 = 8	1/1/1 = 3	0/0/1/0/1/1/1 = 4	1/1/0/0/1/0 = 3	0	18
2012 Mrkonjic et al.	IV	1/1/1/1/1/1/1/0/1/1 = 9	1/0/1 = 2	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	19
2015 Mrkonjic et al.	IV	1/1/1/1/1/1/1/0/1/1 = 9	1/0/1 = 2	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	19
2015 Kasapinova et al.	IV	1/1/1/1/2/1/1/0/1/1 = 10	1/1/1 = 3	0/0/1/1/1/1/1 = 5	1/1/0/0/1/1 = 4	0	22
2017 Swart et al.	IV	1/1/1/1/1/1/1/0/1/1 = 9	1/1/1 = 3	0/0/1/1/1/1/1 = 5	1/1/0/0/0/1 = 3	0	20

measured after 12 and 24 months was significantly smaller in the arthroscopy group. Another randomised trial, by Yamazaki et al. [6], found no evidence that arthroscopy was better than fluoroscopy for guiding the reduction of IADRFs. The 74 patients were randomised to arthroscopic or fluoroscopic guidance of reduction followed by volar locking plate fixation. Step-off and inter-fragmentary gap were assessed on radiographs obtained after 6 and 48 weeks, by 2 orthopaedic surgeons who had not participated in treating the patients. Neither parameter was significantly different between the two groups. Finally, a study by Thiart et al. [17] of 44 patients with a mean age of 42 years used fluoroscopy to guide internal fixation, followed by intra-operative arthroscopy to assess the results. These were usually satisfactory, suggesting that adding arthroscopy to assist the reduction would probably not provide substantial benefits.

The literature thus seems conflicting, with some studies suggesting better restoration of joint surface congruity with arthroscopy but others, particularly the most recent, producing less convincing results. However, the numbers of patients were small and, most importantly, follow-up was only 15 months on average. Finally, several studies provided only level IV evidence that did not allow for comparisons of the clinical and radiographic outcomes.

4.2. How does arthroscopy contribute to the diagnosis and treatment of concomitant ligament injuries?

The results about ligament injuries are contradictory. The available evidence do not provide proof that arthroscopy is an effective treatment. In contrast, arthroscopic assistance is recognised as considerably improving the diagnosis and classification of these same acute ligament injuries.

SLIL injuries were found in over 40% of patients, although only about one-fourth were complete tears that sometimes required scapholunate pinning or arthroscopic repair. Arthroscopy is particularly valuable in this situation due to its high diagnostic performance and ability to allow same-stage treatment of complete SLIL tears, thereby potentially preventing the development of osteoarthritis. Nonetheless, studies with longer follow-ups are needed to confirm the benefits of arthroscopy. Partial Geissler grade 1-2 SLIL injuries were left untreated. No studies assessing the potential long-term impact of these partial lesions in patients with IADRFs were identified.

TFCC injuries were even more common, as they were found in over 48% of patients. Type 1B, defined as peripheral ulnar TFCC detachment, was the type most often managed by arthroscopic repair. This fact reflects the high rate of healing of type 1B injuries, which is ascribable to the peripheral blood supply to the TFCC via branches of the anterior inter-osseous and ulnar arteries [31]. The other types of TFCC lesions were usually managed only by arthroscopic debridement. The short patient follow-up durations precluded an assessment of the outcomes of this treatment strategy.

Overall, the use of arthroscopy in patients with IADRFs identified a large number of concomitant carpal injuries and allowed the same-stage treatment of severe SLIL injuries and of peripheral ulnar TFCC detachment. Many of the available studies are case series with short follow-ups. Prospective comparative studies with longer follow-up durations would help to clarify whether arthroscopy benefits the management of carpal lesions in patients with IADRFs.

4.3. Does arthroscopy help to improve the functional scores at last follow-up?

On this point also, divergences exist in the published data. The studies that analysed or compared subjective or objective functional scores had a mean follow-up of only 30 months, with half of them having follow-ups no longer than 12 months. Most of the data come from case-series studies, which showed good outcomes at last follow-up. In 4 of these case-series studies, arthroscopy was felt to produce benefits by decreasing the size of the scar [13] and by allowing plate pre-positioning to decrease the invasiveness of the procedure [10]. Nonetheless, 3 other case-series studies did not support a beneficial impact of arthroscopy. Thus, Levy et al. [9] found no correlation between the anatomical ligament injuries and the deficiencies in articular surface restoration after 1 year. The 35 patients had a mean age of 78 years and were managed by pinning. Arthroscopy was performed to assess the ligament injuries and quality of reduction at pin removal 6 weeks later. Few patients had a step-off or a greater than 1-mm inter-fragmentary gap. The

pragmatic conclusion that joint reduction with arthroscopic assistance should be reserved for younger patients was subsequently supported by two other case-series studies with follow-ups of 1 year [17,26].

The findings from prospective comparative studies are similarly conflicting. Varitimidis et al. [4] suggested that treating the concomitant ligament injuries may have contributed to improve the functional scores. After 12 and 24 months, the group managed using arthroscopy had significantly better Mayo Wrist Score results, as well as non-significantly better DASH scores. On the other hand, Yamazaki et al. [6] found no evidence that arthroscopic assistance improved the functional outcomes in a randomised study that provided level II evidence. Two independent observers measured grip strength and assessed the DASH score, which showed no significant between-group differences at 6 or 48 weeks. Thus, with a randomised design, this study was not in favour of arthroscopic assistance.

5. Conclusion

Studies of the contribution of arthroscopic assistance to accurate articular surface restoration in patients with IADRFs have produced conflicting results. Several of these studies used a case-series design and had short follow-up durations.

In contrast, the available data constitute convincing evidence that arthroscopy is valuable for diagnosing and classifying concomitant ligament injuries, as well as for providing treatment orientation. Arthroscopic assistance allowed the same-stage treatment of ligament injuries. Arthroscopically diagnosed lesions were common but often partial. Partial SLIL injuries were usually left untreated. Peripheral ulnar TFCC injuries were repaired, whereas other TFCC lesions were managed only by debridement. The follow-up duration in the available studies is too short for an assessment of the outcomes of these lesions diagnosed and/or treated during the management of IADRFs.

Finally, the case-series design and short follow-ups of many of the published studies preclude definitive conclusions about whether arthroscopy improves the functional scores at last follow-up.

Randomised controlled studies using a single internal fixation method in large and uniform patient populations are needed. The populations in the studies performed to date are heterogeneous in terms of fracture type and, most importantly, patient age. Ligament lesions in older patients may be related to degenerative disease rather than to injury. Longer follow-ups are needed to:

- evaluate whether radio-carpal osteoarthritis can be prevented by accurate articular surface restoration and/or has adverse effects;
- evaluate the potential and as yet unknown consequences of partial SLIL and TFCC lesions managed by arthroscopic debridement;
- clarify the role for early arthroscopic treatment of complete SLIL tears and peripheral TFCC detachment.

Disclosure of interest

The authors declare that they have no competing interest.

Funding

None.

Authors' contributions

E. Guerre contributed to the literature database search.

C. Chantelot contributed to the literature database search and participated in the 2017 SoFCOT symposium on minimally invasive and arthroscopic techniques.

M. Ehlinger directed the 2017 SoFCOT symposium on minimally invasive and arthroscopic techniques, wrote the manuscript, and revised the manuscript for important intellectual content.

Th. Bauer participated in the 2017 SoFCOT symposium on minimally invasive and arthroscopic techniques and revised the manuscript for important intellectual content.

Ph. Clavert participated in the 2017 SoFCOT symposium on minimally invasive and arthroscopic techniques and revised the manuscript for important intellectual content.

References

[1] Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ 2015;350:g7647.
[2] Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health 1998;52:377–84.
[3] Battistella F, Taverna E. Wrist arthroscopy in intra-articular distal radius fracture (SS-61). Arthroscopy: The Journal of Arthroscopic & Related Surgery 2007;23:e30–1, http://dx.doi.org/10.1016/j.arthro.2007.03.075.
[4] Varitimidis SE, Basdekis GK, Dailiana ZH, Hantes ME, Bargiotas K, Malizos K. Treatment of intra-articular fractures of the distal radius: fluoroscopic or arthroscopic reduction? J Bone Joint Surg Br 2008;90:778–85, http://dx.doi.org/10.1302/0301-620X.90B6.19809.
[5] Burnier M, Herzberg G, Izem Y, Joulie S. Traitement des fractures articulaires du radius distal sous arthroscopie: le but anatomique est-il atteint? Revue de Chirurgie Orthopédique et Traumatologique 2013;99:e22, http://dx.doi.org/10.1016/j.rcot.2013.10.061.
[6] Yamazaki H, Uchiyama S, Komatsu M, Hashimoto S, Kobayashi Y, Sakurai T, et al. Arthroscopic assistance does not improve the functional or radiographic outcome of unstable intra-articular distal radial fractures treated with a volar locking plate: a randomised controlled trial. Bone Joint J 2015;97–B:957–62, http://dx.doi.org/10.1302/0301-620X.97B7.35354.
[7] Christiaens N, Nedellec G, Guerre E, Guillou J, Demondion X, Fontaine C, et al. Contribution of arthroscopy to the treatment of intraarticular fracture of the distal radius: Retrospective study of 40 cases. Hand Surgery & Rehabilitation 2017;36:268–74.
[8] Hardy P, Gomes N, Chebil M, Bauer T. Wrist arthroscopy and intra-articular fractures of the distal radius in young adults. Knee Surg Sports Traumatol Arthrosc 2006;14:1225–30, http://dx.doi.org/10.1007/s00167-006-0123-9.
[9] Levy S, Saddiki R, Normand J, Dehoux E, Harisboure A. Arthroscopic assessment of articular fractures of distal radius osteosyntheses by percutaneous pins. Chir Main 2011;30:218–23, http://dx.doi.org/10.1016/j.main.2011.04.004.
[10] Abe Y, Yoshida K, Tominaga Y. Less invasive surgery with wrist arthroscopy for distal radius fracture. J Orthop Sci 2013;18:398–404, http://dx.doi.org/10.1007/s00776-013-0371-8.
[11] Khanchandani P, Badia A. Functional outcome of arthroscopic assisted fixation of distal radius fractures. Indian J Orthop 2013;47:288–94, http://dx.doi.org/10.4103/0019-5413.109872.
[12] Del Piñal F, Klausmeyer M, Moraleda E, de Piero GH, Rúas JS. Arthroscopic reduction of comminuted intra-articular distal radius fractures with diaphyseal-metaphyseal comminution. J Hand Surg Am 2014;39:835–43, http://dx.doi.org/10.1016/j.jhsa.2014.02.013.
[13] Zemirline A, Taleb C, Facca S, Liverneaux P. Minimally invasive surgery of distal radius fractures: a series of 20 cases using a 15 mm anterior approach and arthroscopy. Chir Main 2014;33:263–71, http://dx.doi.org/10.1016/j.main.2014.04.007.
[14] Lutsky K, Boyer MI, Steffen JA, Goldfarb CA. Arthroscopic assessment of intra-articular distal radius fractures after open reduction and internal fixation from a volar approach. J Hand Surg Am 2008;33:476–84, http://dx.doi.org/10.1016/j.jhsa.2007.12.009.
[15] Ono H, Furuta K, Fujitani R, Katayama T, Akahane M. Distal radius fracture arthroscopic intraarticular displacement measurement after open reduction and internal fixation from a volar approach. J Orthop Sci 2010;15:502–8, http://dx.doi.org/10.1007/s00776-010-1484-y.
[16] Ono H, Katayama T, Furuta K, Suzuki D, Fujitani R, Akahane M. Distal radial fracture arthroscopic intraarticular gap and step-off measurement after open reduction and internal fixation with a volar locked plate. J Orthop Sci 2012;17:443–9, http://dx.doi.org/10.1007/s00776-012-0226-8.
[17] Thiart M, Ikram A, Lamberts RP. How well can step-off and gap distances be reduced when treating intra-articular distal radius fractures with fragment specific fixation when using fluoroscopy. Orthop Traumatol Surg Res 2016;102:1001–4, http://dx.doi.org/10.1016/j.otsr.2016.09.005.
[18] Müller ME, Nazarian S, Koch P. Classification AO des Fractures: Tome I: les os Longs. 1st ed Berlin, Germany: Springer-Verlag; 1987 [Part 2. n.d].

[19] Hattori Y, Doi K, Estrella EP, Chen G. Arthroscopically assisted reduction with volar plating or external fixation for displaced intra-articular fractures of the distal radius in the elderly patients. Hand Surg 2007;12:1–12, http://dx.doi.org/10.1142/S021881040700333X.
[20] Mrkonjic A, Lindau T, Geijer M, Tägil M. Arthroscopically diagnosed scapholunate ligament injuries associated with distal radial fractures: a 13- to 15-year follow-up. J Hand Surg Am 2015;40:1077–82, http://dx.doi.org/10.1016/j.jhsa.2015.03.017.
[21] Mrkonjic A, Geijer M, Lindau T, Tägil M. The natural course of traumatic triangular fibrocartilage complex tears in distal radial fractures: a 13-15 year follow-up of arthroscopically diagnosed but untreated injuries. J Hand Surg Am 2012;37:1555–60, http://dx.doi.org/10.1016/j.jhsa.2012.05.032.
[22] Forward DP, Lindau TR, Melsom DS. Intercarpal ligament injuries associated with fractures of the distal part of the radius. J Bone Joint Surg Am 2007;89:2334–40, http://dx.doi.org/10.2106/JBJS.F.01537.
[23] Araf M, Mattar Junior R. Arthroscopic study of injuries in articular fractures of distal radius extremity. Acta Ortop Bras 2014;22:144–50, http://dx.doi.org/10.1590/1413-78522014220300813.
[24] Ogawa T, Tanaka T, Yanai T, Kumagai H, Ochiai N. Analysis of soft tissue injuries associated with distal radius fractures. BMC Sports Sci Med Rehabil 2013;5:19, http://dx.doi.org/10.1186/2052-1847-5-19.
[25] Kasapinova K, Kamiloski V. Influence of associated lesions of the intrinsic ligaments on distal radius fractures outcome. Arch Orthop Trauma Surg 2015;135:831–8, http://dx.doi.org/10.1007/s00402-015-2203-0.
[26] Swart E, Tang P. The effect of ligament injuries on outcomes of operatively treated distal radius fractures. Am J Orthop 2017;46:E41–6.
[27] Geissler WB, Freeland AE, Savoie FH, McIntyre LW, Whipple TL. Intracarpal soft-tissue lesions associated with an intra-articular fracture of the distal end of the radius. J Bone Joint Surg Am 1996;78:357–65.
[28] Messina JC, Van Overstraeten L, Luchetti R, Fairplay T, Mathoulin CL. The EWAS classification of scapholunate tears: an anatomical arthroscopic study. J Wrist Surg 2013;2:105–9, http://dx.doi.org/10.1055/s-0033-1345265.
[29] Palmer AK. Triangular fibrocartilage complex lesions: a classification. J Hand Surg Am 1989;14:594–606.
[30] Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. Annals of the Rheumatic Diseases 1957;16:494–502, http://dx.doi.org/10.1136/ard.16.4.494.
[31] Skalski MR, White EA, Patel DB, Schein AJ, RiveraMelo H, Matcuk GR. The Traumatized TFCC: an illustrated review of the anatomy and injury patterns of the triangular fibrocartilage complex. Curr Probl Diagn Radiol 2016;45:39–50, http://dx.doi.org/10.1067/j.cpradiol.2015.05.004.