Research Article

The Arthroscopic-Assisted Reduction of Wrist Fracture is Worth the Reward? Single Centre Experience

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ABSTRACT

Objectives/Interrogation: The goal of wrist fractures remains anatomic reduction. In literature is reported a considerable number of injuries of inter-carpal ligaments and Triangular Fibro Cartilage Complex associated (TFCC) to wrist fractures that were not detected or were underestimated using only intraoperative fluoroscopy. We proposed a retrospective study of single centre experience on arthroscopic-assisted treatment of wrist fractures analyzing number of associated lesions, costs and complications. The purpose is demonstrated that arthroscopy is fundamental in wrist fractures to optimize fracture reduction and to diagnose and treat associated lesions.

Methods: 78 patients were treated for wrist fractures with open volar approach assisted with wrist arthroscopy. Maximum 1mm gap on articular surface is accepted. Integrity of scafolunate, lunotriquetral ligaments and TFCC was checked using standard tests. TFCC lesions were classified using Palmer and Atzei classifications. We analyzed the duration of operation and arthroscopy. We evaluated the outcomes in terms of range of motion, return to work and major and minor complications.

Results and Conclusion: We observed 43 associated injuries of TFCC. 37% of TFCC lesions were Type 1 sec Palmer. Type 1B was sub-classified using Atzei classification and we observed 2 type D, 4 type P and 2 type C. Arthroscopic debridement was used for degenerative and type P lacerations. All type D and type C lacerations were treated arthroscopically. In 28% of cases a correction of osteosynthesis assisted by arthroscopy was necessary. Mean operation time was 57 minutes. We observe a good range of movement and an acceptable time to return to work.

The use of arthroscopy in our cases was fundamental to diagnose and treat associated lesions to wrist fractures. Using Atzei classification we avoid to over treating TFCC lesions and we fixed that one created a real instability on distal radio-ulnar joint. We could correct a considerable number of ostheosyntesis that would be underestimated without arthroscopy.

The addition of arthroscopy doesn't increase significantly times and cost of procedures in particular if we consider that we could customize the postoperative rehabilitation protocol avoiding secondary operations to treat or diagnose associated lesions.

Despite in literature there is not a consensus about arthroscopic-assisted reduction of wrist fracture we believe that it is fundamental to diagnose and treat associated lesion in wrist fractures and to obtain a precise reduction of fracture.

INTRODUCTION

The goal of intra-articular distal radius fracture remains anatomic reduction to decrease the risk of development of posttraumatic osteoarthritis of distal radio-ulnar and radio-carpal joints [1,2]. In literature two different main approaches are described to avoid intra-articular deformities after distal radius fracture: the dorsal and the volar approach. The volar approach with the application of a locking plate is the most used for intra-articular distal radius fracture [3-5]. The benefits described using this technique is low risk of extensor tendon damage, straightforward surgical dissection, early mobilization and benefits from fixed angle fixation in osteopenic bone. Direct visualization of articular surface would require an arthrotomy disrupting the volar radio-carpal ligaments with the possibility to create wrist instability. The articular surface is indirectly restored reducing epi-metaphyseal fracture fragments. After reduction the adequacy of articular surface are checked using intra operative fluoroscopy [6]. It has been reported that an acceptable articular congruity was obtained if the intra-articular step-off was less than 2 mm to avoid the development of wrist osteoarthritis [7]. In the last few year different studies focused on changing in load on the articular radius surface in relation to intra-articular step-off. Joint loading, kinematics and associated stress distributions, calculated using 3D simulating models, demonstrate that an acceptable intra-articular step-off should be less than 1mm [8]. Moreover different studies in literature reported, using magnetic resonance imaging and intra operative arthrography, a considerable number of injuries of inter-carpal ligaments and Triangular Fibro Cartilage Complex (TFCC) that were not detected or were underestimated using intraoperative fluoroscopy [9-11].

For all these reasons arthroscopy was associated to standard volar approach to diagnose and treat ligaments tears associated to distal radius fracture and to optimize the fracture reduction keeping the target of an intra-articular step-off less than 1 mm [12].

Arthroscopy indications to the treatment of intra-articular wrist fractures are expanding and include diagnostic, reparative and reconstructive procedures [13]. Arthroscopy is useful in intra-articular distal radius fractures because is able to influence different factors like the amount of radial shortening, the articular angulation, the joint congruity and the treatment of associated lesions [14,15]. In the other hand in literature there is not a consensus about the use of arthroscopy for extra-articular fractures. Moreover cost, learning curve, equipment and necessary training have limited the use of wrist arthroscopy. The debate is open about the arthroscopy-assisted management of distal radius fractures long term functional results and outcomes.

In our retrospective non-comparative study we reported a single centre experience of arthroscopic-assisted reduction of wrist fractures analyzing complications, recovery time, operative time and number of associated lesions like TFCC and ligaments tears. The purpose of this study is to demonstrate that arthroscopy is a valid tool to support the osteosynthesis of wrist fractures, to diagnose and treat associated lesions decreasing time of recovery. In our experience the combined open and arthroscopy-assisted fixation do not increase time of surgery and reduce time of fluoroscopy.

MATERIALS AND METHODS

We analyzed 78 patients that underwent surgery from January 2014 to December 2015. All patients were treated for distal radius fracture with an open volar approached assisted with wrist radio-carpal arthroscopy. We performed in 22% of cases a mid-carpal arthroscopy. This approach is reserved for those cases of radiographic evidence of dynamic or static mid-carpal instability or radio-carpal arthroscopy evidence of scapho-lunate or luno-triquetral tears. In those cases we performed arthroscopy to check mid-carpal stability too.

There were 59 women and 19 male. The patient age ranged from 21 to 88 years old (mean age 60 years). More than half of patients (53%) were retired with the expectation of restarting manual activities like gardening, housework activities and non-competitive sports activity (swimming, jogging, gymnastic). Ten patients were manual worker with necessity to come back to hard manual jobs like construction workers, bricklayers and electricians. Twenty-four patients were not hard manual workers but high demanding manual workers. We include in this group those patients that need a fast return to a manual work of high or medium level of precision like medical doctors, dentist assistants, employees, musicians, lawyers and

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student (Table 1). Using AO Trauma classification of distal radius fractures we observed 16 extra-articular fractures (ten type A2 and six type A3), 62 articular fractures type B or C. On these articular fractures we observed one B1, three B2, four B3, forty-one C1, twelve C2 and one C3. Thirty-six patients have injured the dominant hand (Table 2).

Table 1: Patient's demographic data.

Mean age (yrs)	60
Male patients n (%)/Female patients n (%)	19(24)/59(76)
Dominant side fractures n (%)	36(46)
Plate system n (%)	
APTUS	32(41)
Acu-Lock	46(59)
Type of work n (%)	
Retired	41(53)
Hard manual job	10(13)
High demanding manual worker	27(34)

Table 2: Arthroscopy findings.

Arthroscopy findings	n (%)
Total amount of TFCC Lesions	43 (55)
Type 1*	16 (37)
Type 2*	27 (63)
S-L Injuries**	15 (19)
L-T Injuries**	3 (4)
Chondropathy	15 (19)
Intra-articular step-off >1mm	22(28)

*Using Palmer Classifications.

**Geissler classification grade I, without mid-carpal instability.

Preoperative X-ray and CT scan were performed to study the morphology of the fractures and to decide the type of plate using for osteo synthesis.

Moreover in most distal comminuted intra-articular fractures we used 3D printed distal radius models. The 3D printed bone fractures is derived from CT scan images and has an accuracy of 0,1mm [16]. This provides an additional tactile and visual experience increasing the appreciation of articular surface and gaps to better understand fracture's morphology for the preoperatively planning (Figure 1).

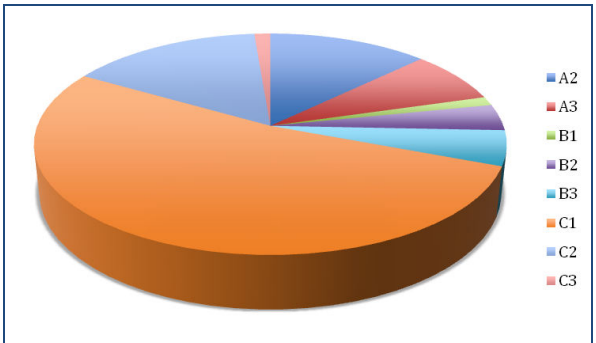

Figure 1: Distribution of distal radius fractures using AO Classification System.

SURGICAL TECHNIQUE

All patients were operated from the same surgeon within the fifth day after the injury under regional anesthesia. Fracture reduction was obtained by horizontal traction and using one or two percutaneous 1.4 K-wires, mobilising the fragments from dorsal and dorsal-radial side of the distal radius. A standard volar approach sec. Henry was performed. Reduction was checked by fluoroscopy. A satisfying reduction was attempt exploiting the ligamentot axis effect without opening the joint even for the intra-articular fractures. When a good reduction was obtained a volar locking plate was applied. Two types of plates were used: Aptus Radius 2.5 (Medatis) or, when preoperative imaging shown one or more dorsal fragments, an Acu-Lock (Acumed) to compact the dorsal fragments withdorsal compression screws. Aptus Radius 2.5 plate was used in 41% of patients and the others fracture was fixed using Acu-Lock plate.

A standard radio-carpal dry arthroscopy was performed. At first during the arthroscopy the surgeon performed synoviectomy and debridement to remove the post-traumatic intra-articular hematoma and inflammatory synovia. In case of an intra-articular step-off or gap more than 1 mm that was corrected repositioning plate and screws assisted by arthroscopy. In case of osteopenic bone allogeneic bone substitute is inserted exploiting the arthroscopic portals. The integrity of scapho-lunate and luno-triquetral ligaments was checked. In that cases in which we observed radiographic signs of scapho-lunate or luno-triquetral instability or in that cases in which we observed some lesion of intrinsic ligaments through radio-carpal arthroscopy, we decided to perform also a mid-carpal arthroscopy. Mid-carpal stability was tested and classified using Geissler classification [17]. TFCC was evaluated using standard tests: hook and trampoline [18]. TFCC lesions were classified using Palmer classification [19]. Moreover the Type 1B sec. Palmer lesions were sub-classified using Atzei classification [18]. Three standard projections were performed as final intra operative fluoroscopy control. Each patient followed a specific postoperative rehabilitation protocol for 12 week after surgery with the same therapist. Patients had first postoperative visit at 6 weeks and the second one at 12 weeks with X- ray.

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RESULTS

During the arthroscopic evaluation we observed a total of 43 associated injuries of TFCC, 15 injuries to the scapho-lunate ligament, 3 to luno-triquetral ligament and in 15 cases we observed a carpal chondropathy of the scaphoid or lunate joint surface (Table 2). Using Palmer classification we observed that 37% of associated injuries of TFCC were post-traumatic (Type 1) and 63% were degenerative (Type 2). In the context of Type 1 lesions we reported seven central perforations of TFCC (Type 1A), eight ulnar avulsions (Type 1B) and one radial avulsion (Type 1D). Regarding Type 2 TFCC lesions we observed three Type 2A, seventeen Type 2B and even Type 2C.

The eight cases of Type 1B were sub-classified using Atzei classification. We observed4 distal lacerations (Type D), 2 proximal lacerations (Type P) and 2 combined lacerations (Type C) (Table 3).

Table 3: Classifications and distribution of TFCC lesions.

TFCC Lesions n (%)	43 (55)
Palmer Classification	
Type 1	16 (37)
1A	7 (16)
1B*	8 (18)
1D	1 (2)
Type 2	27 (63)
2A	3 (7)
2B	17 (39)
2C	7 (16)
Atzei Classification n(%)*	
Type D	4 (50)
Type P	2 (25)
Type C	2 (25)

*Atzei classification for Type 1B (percentage is calculated on total amount of Type 1B lesions).

Degenerative lesions were treated through the debridement of TFCC region

Distal lacerations (Type D) were treated with suture ligaments capsule, proximal lacerations (Type P) were treated with trans-osseous foveal re-fixation and two combined lacerations (Type C) were also treated with trans-osseous re-fixation to the fovea.

In 28% of cases, using arthroscopy, we observed an articular step-off surface higher than 1 mm or the presence of small fragments that required a correction of reduction and implant replacement assisted by arthroscopy (Table 2).

Mean operative time was 57 minutes included the mean time of arthroscopy that was 20 minutes.

The mean range of movement obtained after the specific rehabilitation protocol was: extension/flexion 55-0-57, pronation/supination 74-0-71, radial/ulnar deviation 14-0-15.

We observed four major complications: two mal-unions, treated with new osteosynthesis using bone graft after four months and two Complex Regional Pain Syndromes (CRPS) treated with systemic corticosteroids and removal of the osteosynthesis material. In five cases rigidity in extension/flexion or rotation were reported at 6 and 12 weeks after operation but CRPS was excluding using Budapest criteria and it was solved with rehabilitation therapy.

The mean time of complete returning to work was 3, 4 months.

DISCUSSION

The goal of Open Reduction and Internal Fixation (ORIF) in wrist fractures is to obtain an anatomical reduction. Intra-articular displacement in distal radius fracture should be less <1mm as reported by Doi et al., [1] and Fernandez et al [20]. A step off > 1mm lead to irreversible changing on joint surface load that could bring to post-traumatic osteoarthritis and articular pain [8-21]. Now a day a volar approach, using a locking plate, is the most used method for the reduction and fixation of intra-articular distal radius fracture. The correct plate positioning and fracture reduction are verified using intraoperative fluoroscopy. In the last few years wrist arthroscopy has been proposed to verify the congruity of articular surface and the presence of articular displacement on radio-carpal joint surface.

Previous studies have examined the reliability of intraoperative fluoroscopy to assesintra-articular distal radius fractures reduction [1] found a statistically significant difference between the degree of articular gap measured by radiographs and by arthroscopy. Arthroscopy visualization of joint surface revealedan intra-articular step-off > 1mm in 33% of their patients. Doi et al. compared open reduction and internal fixation versus arthroscopically assisted external fixation and demonstrated that arthroscopically reduction was better than reduction without arthroscopy [22]. In our experience in 28% of cases we observed a step-off> 1mm

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after open reduction and internal fixation even though the intraoperative fluoroscopy shows a good articular congruity. Through the arthroscopy we could check the articular surface and optimize the reduction respecting an intra-articular step-off less than 1 mm; otherwise, in our experience, is not possible to obtain this target using onlystandard intraoperative fluoroscopy. There are different explanations about these findings: fluoroscopy images are not so defined like arthroscopy images; fluoroscopy is useful to observe a line of fracture but is not so precise to detect the degree of deplacement of intra-articular fragments; moreover fluoroscopy doesn't show the cartilage surface and that could underestimate an intra-articular step.

Several reports in literature show that distal radius fractures, both intra- and extra articular, have a high incidence of associated injuries like chondral and soft tissue injuries [23-25]. The most frequents are Triangular Fibro Cartilage Complex (TFCC) and Scapho-Lunate Interosseus Ligament (SLIO) tears in a range between 48% to 78 % for TFCC tears and 8 to 85% for SLIO tears [26-31]. Palmer classification of TFCC lesions is the most used to classify and choose the better treatment. Atzei et al. proposed a new sub-classification of Types 1B lesions according to Palmer classification [18-32]. Atzei classification is based on anatomical localization of lesion. We consider that Type 1B lesions are the most frequently associated to distal radius fracture and the most subjected to create DRUJ instability. Atzei observed that TFCC is composed by a proximal component (pc-TFCC) and a distal component (dc-TFCC) [32,33].

Using trampoline and hook tests is possible to observe tears on pc-TFCC (Type P), tears on dc-TFCC (Type D) or combined lesions (Type C). During our arthroscopies we observed 37% of TFCC post-traumatic lesions with eight cases of ulnar avulsion of TFCC (Palmer Type 1B). In these kind of lesions Atzei classification has been proven more reliable on understand the instability on DRUJ and congenial for taking the decision if re-fix or not the tears on TFCC. According with Atzei classification we decided to perform a trans-osseous re-fixation on that tear on proximal component of TFCC (Type P) and combined tears (Type C); for distal component of TFCC (Type D) tears we proposed a suture ligament capsule.

As reported in literature the range of associated lesions, like TFCC or ligaments lesions, is very wide. We could use pre-operative or intra operative clinical tests that should help to diagnose a DRUJ or mid-carpal instability but they are not so reliable. Is very difficult to manipulate the wrist preoperatively due to the pain and when is performed under loco-regional anesthesia, there is a lost of function of the secondary stabilizer of DRUJ for these reasons the reliability of pre-operative and intra-operative clinical tests is poor. In our opinion arthroscopy is the gold standard to diagnose and, if is necessary, to treat at the same time the associated lesions to distal radius fractures, to evaluate and optimise the congruency of the articular surface and to detect intra-articular screws without overusing the fluoroscopy.

In case of associated lesions involving radio-carpal and mid-carpal ligaments, arthroscopy resulted useful to evaluate the joint stability created by inter-osseous ligaments tears. We observed 19% of S-L injuries and 4% of L-T partial injuries, through the arthroscopy we verified also the radio-carpal and mid-carpal stability and we don't need to treat them. At the same time we could customize the postoperative rehabilitation protocol because we were conscious about the presence of that kind of associated lesions. Even though those lesions didn't create instability they required a specific rehabilitation protocol to obtain good functional results. In our experience CT scan and, in selective cases, 3D printed models are useful to better understand the morphology of fractures. In 61% of cases we notice at the CT scan a dorsal-ulnar fragment that involved the DRUJ. Using arthroscopy, in those cases, we decide to use a volar plate with a special screw compression system that permit to attempt the dorsal- ulnar fragment without open dorsal approach. Moreover in comminuted fractures, if we decide to put more distally or sub-chondral screwsto sustain the articular surface, arthroscopy allows usto check the articular surface avoiding intra-articular wrong screw positioning.

One of the restrictions to the arthroscopic management of distal radius fractures is that the procedure could increase the time of operation and consequently the cost of the procedure. In our experience the mean time of the procedure added to the time of arthroscopy overlap the mean time of volar locking plate positioning without arthroscopy reported in literature [33]. In

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our retrospective study the review of single centre experience confirms that arthroscopy is a valid support in distal wrist fractures management. Obviously arthroscopy requires a learning curve but the advantages due to this procedure, the possibility to restore the articular surface in a very high precision way and to diagnose and treat associated lesion led us to strongly support and suggest the use of this technique. Randomized and comparative studies with longer follow-up are necessary to demonstrate if the arthroscopy-assisted management could improve also the long-term functional results and outcomes avoiding post-traumatic wrist osteoarthritis.

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