



## Minimally Invasive Plate Osteosynthesis and Clinical Outcomes in Distal Radius Fracture

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**DOI:** 10.31080/ASOR.2024.07.0897

**Received:** January 19, 2021

**Published:** January 18, 2024

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### Abstract

This prospective study presents the results of the surgical management of distal radius fractures using the Minimally Invasive Plate Osteosynthesis (MIPO) technique between the years 2015 and 2019, with a follow-up of one year, which took place in Hospital San Juan de Dios in Curicó, Chile. The evaluated features were the type of fracture and surgical time. The functional scale was evaluated using the Patient Rated Wrist Evaluation (PRWE), other variables (which will be described further on) were also evaluated.

The MIPO surgical approach performed in this study was mainly transverse, only in 2 cases a longitudinal one was used.

This type of surgical approach is increasingly used not only for cosmetic results, but for the quickest recovery of the patient and because its clinical and radiological results are comparable to those of the extended classical approach. This technique is mainly used in extra articular fractures or simple intra-articular fractures.

In this study 35 patients were evaluated, of which 26 (72.22%) were men. The average age, during the 5 years of study, was 40.4 years in the male group (range 21 - 67) and 34.25 years in the female group (range 22 - 54). Regarding the classification of fractures, the classification proposed by the AO-ASIF was used, being the type 23-a2 and 23-a3 fractures the most common, the rest was distributed between B3, C1 and C2 fractures. The shortest surgical time was 43 minutes, and the longest was 94 minutes, with an average surgical time -in the five years the study was conducted- of 73.49 minutes.

The functional outcomes of the patients were evaluated using the Patient Rated Wrist Evaluation (PRWE), the average results during the 5 years in both groups (men, women) were 27.82 in the follow up made 3 weeks after the operation and 6.53 in the final examination done 1 year after.

Finally, Range of Articular Movement (RAM) was evaluated 1 year after the operation, these were on average 79 - 78 degrees, wrist extension: 69 - 69 degrees, pronation: 90 - 85 degrees, wrist supination: 90-85 degrees in both groups of men and women respectively.

The MIPO technique is a beneficial option with a series of important advantages, but it must be known by the surgeon and duly indicated to obtain the best results.

It is a technique with a relatively fast learning curve, but even in experienced hands conversion to an open procedure may become necessary.

**Keywords:** Minimally Invasive Plate Osteosynthesis; Distal Radius Fracture; Range of Articular Movement (RAM)

## Introduction

Distal radius fractures (DRF) are one of the most frequent upper extremity fractures [1] both in the elderly and young population, being more frequent in women. This type of fracture may occur in elderly patients with osteoporotic bone due to low-energy trauma and due to high-energy trauma in young patients with healthy bone. According to Zhang Y distal radius fractures accounted for more than 4% of fractures in adults and up to 12% in the elderly, only behind hip and spinal fractures [2].

Treatment depends on the pattern and stability of the fracture. Since the early 2000s, the ORIF of this fracture using an anatomical volar locked plate has been associated with better clinical outcomes and functional recovery, even in fractures with dorsal involvement [3] and it has become the gold standard in the management of this fracture [4]. These plates can be inserted using different types of surgical approaches, being the conventional approach to the flexor carpi radialis (FCR), the extended FCR approach and the minimally invasive FCR approach the most frequently used [5].

The conventional technique of open reduction and internal fixation with plates involves an extended approach and detachment of soft tissues to achieve an anatomical reduction, with the commitment of blood irrigation of fractured fragments, which could increase the risk of infection and non-union [6].

In 2005, Imatani, *et al.* reported for the first time 5 cases with distal radius comminuted fracture, achieving reduction and internal fixation through a minimally invasive approach with two longitudinal incisions (3 cm) on the palmar side of the distal forearm [7].

Minimally invasive plate osteosynthesis (MIPO) has 3 important characteristics: small skin incision with more aesthetic results, minimal soft tissue dissection near the fracture and muscle preservation of the square pronator (quadratus) [8].

Currently, MIPO technique indications may vary, these have expanded with the passing of the years and the arrival of arthroscopic assistance [9,10].

Xu Ming Wei, *et al.* describe as indications for the MIPO technique use fractures type A2, A3, B1, B3, C1, C2 of the AO-ASIF classification [7], Imatani, *et al.* only indicates it in simple fractures

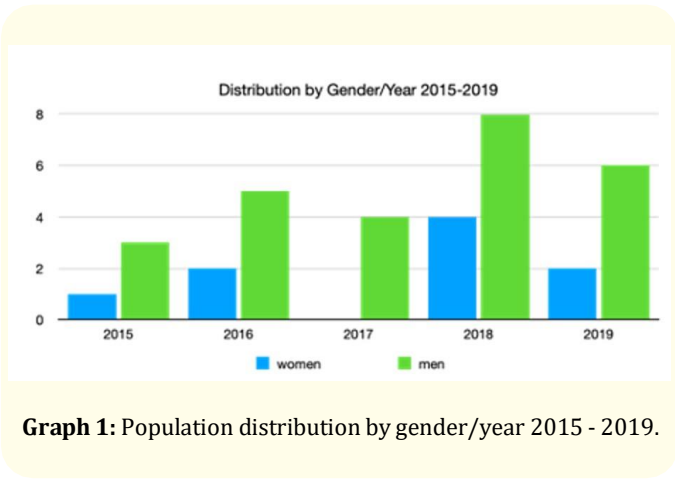
[6], Zenke, *et al.* started indicating them in 2011 in intraarticular fractures [11] and Wei, *et al.* started including them in fractures with meta-diaphyseal involvement [12]. A Senthil Kumar, *et al.* use as inclusion criteria patients older than 20 years, closed fractures, traces of extra articular fracture or minimal intra articular involvement, and as exclusion criteria patients younger than 20 years, compound fractures, severe comminution and severe osteoporosis [13].

## Methods

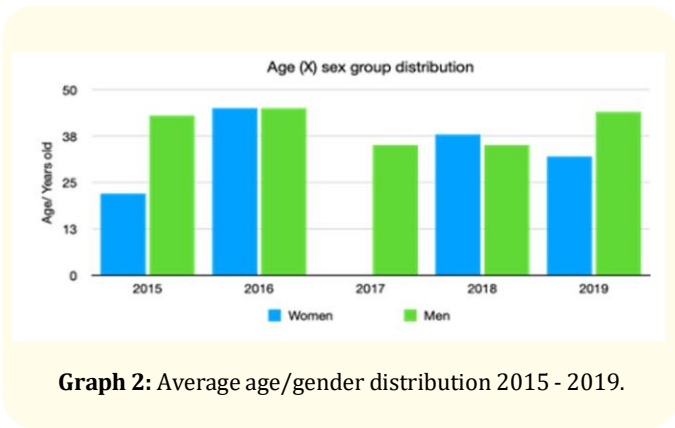
In this study 37 patients with distal radius fractures (37 fractures) were evaluated, the surgery procedure was performed by the same senior surgeon (author of this paper), all patients were informed of the procedure they would undergo and all signed the consent form. In this study 26 patients were men and the rest were women. Inclusion criteria in this work were: type of fracture (AO-ASIF 23-A2, A3, B3, C1, C2), fracture's evolution time between 0 and 10 days, closed distal radius fractures, single fracture (only one wrist with or without ulnar styloid fracture), and adult patients 18 years of age or older. The operated fractures were classified according to the AO-ASIF classification, these being 23-A2, A3, B3, C1, C2 [14]. The surgeries were performed between February 2015 and August 2019, all done by the same Senior surgeon, of a total of 37 surgeries, one was assisted arthroscopically and another one had to be reconverted to open procedure, so it was decided not to include them in this study. Follow-up and examination were performed 3 weeks after the surgery, then after 1 month and finally after 1 year, in this manuscript only the three weeks and one year follow up results are analyzed (see results).

Formal rehabilitation treatment usually begins 2 to 4 weeks after surgery. In this study, the type of rehabilitation protocol used in patients is beyond the objectives of the research. The first postoperative checkup is performed three weeks after the surgery evaluating the satisfaction of the patient (simply asking if he or she was satisfied or not with the surgery at that time), the conditions of the wound and the presence of any sensory-motor deficit or pain are analyzed. The PRWE scale was applied and the flexion, extension, pronation and supination ranges compared to the healthy wrist were evaluated, the same procedure was also performed at the final follow up, one year later. None of the 35 patients abandoned the study or missed the follow ups. All patients had returned to their pre-fracture work or activities. Graph 1 and 2 show the rest of the

demographic data of the patient population that participated in the study (See graph 1 and 2).



**Graph 1:** Population distribution by gender/year 2015 - 2019.



**Graph 2:** Average age/gender distribution 2015 - 2019.

**Surgical technique**

The technique used was the one described by Dr. Liverneaux [15], slightly modified. The procedure starts performing a close reduction of the fracture, manipulation and transient fixation with Kirschner wire (K wire) of bone fragments that require it, once an acceptable reduction is achieved, a 2.5 cm transverse or longitudinal incision is made in the flexor carpi radialis (FCR), the fascia and FCR subsheath is released, then the flexor pollicis longus (FPL) is released, once this is done the vascular bundle of the radial nerve is separated to the radial side, the rest of the elements (median nerve, FCR, FPL) are ulnarly lateralized, then a transverse incision is made in the distal portion of the pronator quadratus (PQ) through which the plate is inserted (Aculock 2 ACUMED/variable angle, Synthes), and any remaining displacement is corrected.



**Figure 1:** MIPO vertical approach. During surgery X-rays.



**Figure 2:** IPO horizontal approach. During surgery X-rays.

**Results**

Distribution of the fractures according to the AO-ASIF classification is detailed in table 1. Average surgery time was 72 minutes, the shortest surgery being 43 minutes and the longest one 94 minutes (See table 2). Evaluation of the function using the PRWE system was done in the first (3 weeks after the procedure) and last (1 year after the procedure) of the planned scheduled investigation follow ups, constant improvement seen in the last examination was remarkable (See graph 3), as well as ROM ranges (wrist flexion, ex-

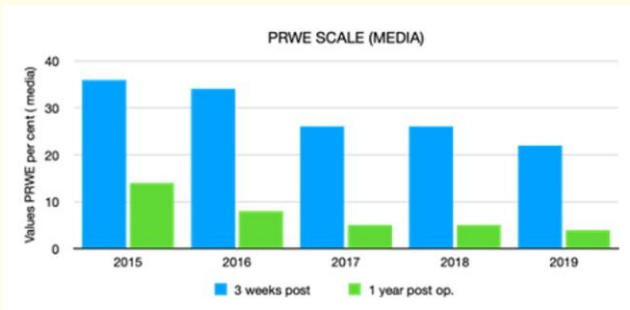
tension, pronation and supination) (See figure 3-5) which showed a clear improvement, this data was only recorded at the last follow up (one year), see results in graph 4.

	Women	Men
A2	2	10
A3	4	6
B3	2	4
C1	0	4
C2	1	2

Table 1: AO-ASIF classification distribution by gender.

Year	Time
2015	86
2016	75
2017	67
2018	72
2019	59

Table 2: Average surgical time distribution by year 2015 - 2019.



Graph 3: PRWE Score average at week 3 and year 1 distribution by year 2015 - 2019.

The satisfaction evaluation, as initially mentioned, was done simply by asking whether or not they were satisfied with the surgery, all patients responded yes, regardless of the complexity of the fracture. As for the return to previous activities, in the women's group 4 (44.4%) were dedicated to housework and were able to



Figure 3: Week 3 post-surgical office control AMA evaluation.



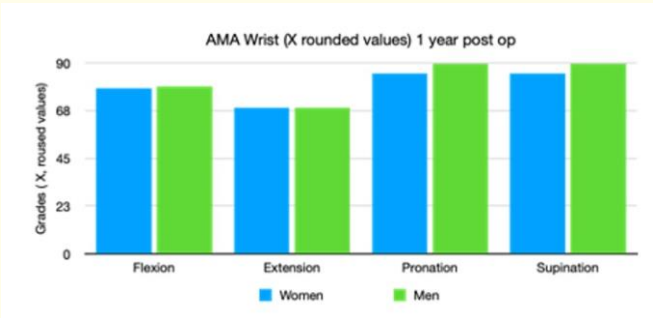
Figure 4: Week 3 post surgical office control AMA evaluation.

resume their activities normally, 2 (22.2%) did office activities and also practiced mountain bike, both returned to their professional and recreational activities, 3 (33.3%) worked at a mutual insurance (ACHS) and also returned to their original jobs. In the men's group, 4 patients (15.3%) requested a change of job, the rest of the





**Figure 5:** Pre surgery X-rays, surgical approach (horizontal), post op x-rays. Week 3 AMA evaluation. Surgical scar aspect.



**Graph 4:** AMA average at year 1 distribution by gender.



male population returned to their previous activities without any change or difficulty, there were 3 (11.5%) cyclists in this population. The cosmetic aspect, mainly in women, was also an aspect that stood out and that strongly influenced the patients patient satisfaction and acceptance of this procedure (See figure 6).

**Statistical analysis**

Relation (multivariable association-multiple correlation) between surgical time and variables of age, gender, year the surgery was made, complexity (AO-ASIF classification) and PRWE.

The Pearson's R association coefficient values were high (0.812) and significant ( $p < 0.01$ ) in relation with the fracture's complexity variable. The other two variables, age and sex, do not show any sig-



**Figure 6:** Final scar: Standard procedure (left), MIPO (right).

nificant association, particularly the patients age. The determination coefficient  $R^2 = 0.659$  has a value between medium and high. In general terms, it can be statistically stated that the variation in the surgical time is determined in 70% by the degree of complexity of the injury and the year of intervention. Other factors considered do not have a significant impact on that variable.

The factors considered in the variable "year of intervention" include especially the degree of skill of the surgeon and his team, organization level of the service and others. The other two variables, age and gender, show no significant association, particularly the age of the patient.

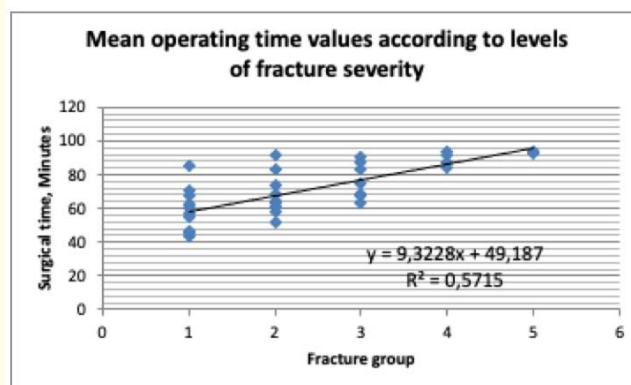
The  $R^2$  determination coefficient has an even value. In general terms, it can be statistically stated that the variation of the surgical time is determined in 50% of the cases by the degree of complexity of the injury (AO-ASIF classification). Other factors considered have no significant impact on that variable. Factors that were not considered in the study such as the degree of skill of the surgeon or others could influence the remaining variation.

The average surgical time was 72 minutes with a standard deviation of 16.1 minutes for 68% confidence level. The surgical time of the vast majority of patients in the sample is between  $71 \pm 26.1$  minutes long.

The standard error of estimate is 2.7 minutes, that is, the average of the universe is in a range of  $71 \pm 2.7$  minutes. If you work with a 95% confidence level, the estimated range in which the average value of the universe is found is between 65.5 and 75.6 minutes.

### Mean operating time values according to levels of fracture complexity

The comparison of the surgical time averages of the successive layers of patients according to the level of complexity of the fracture reveals, through the ANOVA test, that the surgical time is significantly increased ( $p = 0.00$ ) in proportion to the fracture's severity. In level 1 (23-A2 AO-ASIF classification), the average was 58.3 minutes while in level 5 (23-C2 AO-ASIF classification), it was 93.7 minutes. The ANOVA test is based on measuring whether the variability between the strata is significantly greater than the variability within the strata. The F distribution coefficient of variability, for 4 degrees of freedom is 10.252 which exceeds the critical value of the respective table (See chart 1).



**Chart 1:** Mean operation time values by fracture AO-ASIF classification. 1: 23-aA; 2: 23-A3; 3: 23-B3; 4: 23-C1; 5: 23-C2.

### Relation between year of the intervention and the PRWE and operating time values

The tendency to the sustained improvement -with small ups and downs- of the results of the services offered (surgeries) is seen in the two outcome variables (PRWE at 3 weeks and at 1 year) in a significant way ( $p < 0.05$ ) and in the surgical time it occurs with a

situation of edge ( $p = 0.062$ ). The 3-week PRWE falls in the period studied (2015 to 2019) from 35.3 to 22.1 points. The 1-year PRWE decreases from 14.3 to 3.9 points in the same period. The surgical time decreases from 86.3 to 59.5 minutes. These are surprising gains.

### Relation between the patients PRWE and gender

The mean difference tests for non-dependent samples show that there are no differences between the two genders regarding both indicators: PRWE 3 WEEKS and PRWE 1 YEAR. The arithmetic averages for both sexes are similar, the same goes for the standard deviation. The t-average difference test yields non-significant values ( $p > 0.05$ ) because such differences have magnitudes that do not exceed the value of the standard error set, i.e. a ratio less than 1 while the critical value is approximately equal to 2.

### Relation between the PRWE and severity of the fracture (AO-ASIF classification)

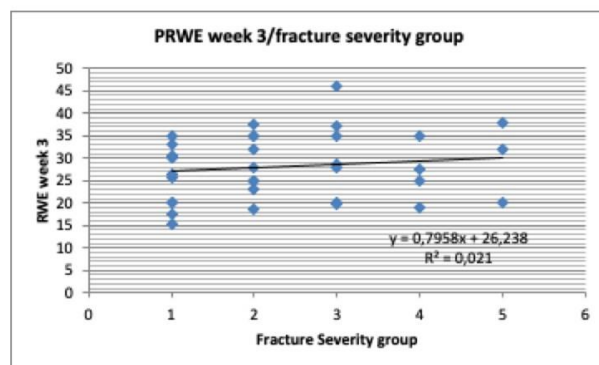
Relation between severity of the fracture (AO-ASIF classification) and the PRWE three weeks after the surgery is, contrary to expectations, surprisingly low  $P^2 = 0.02$ .

This (non)relation between the values of both PRWE with the severity of the fracture was confirmed in the ANOVA test. The mean score values of both indicators are not significantly different from each other. ( $p > 0.05$ ) Same when calculating the mean improvement of the patient's score between the initial value and the end of the observed period.

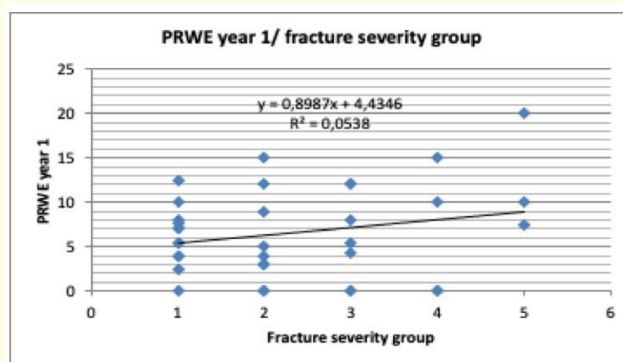
This (non)relation of the 1 year after the procedure PRWE and the severity of the fracture ( $R^2 = 0.024$ ) probably obeys a certain logic: the values of the new PRWE score are independent of the severity of the fracture and are associated with other factors. This result is confirmed when crossing the subtraction of both PRWE (See chart 2 and 3).

### Discussion and Conclusion

In this study the MIPO technique was used for distal radius fractures, this technique was originally described (initially) for the management of femur and humerus fractures [16], however, its use in wrist surgery has had good clinical results objectively evaluated by scales of functionality, with complete patient satisfaction and excellent return to work [17,18]. For this reason, I consider it a fully reproducible technique.



**Chart 2:** PRWE week 3 status by fracture AO-ASIF classification.  
1: 23-aA; 2: 23-A3; 3: 23-B3; 4: 23-C1; 5: 23-C2.



**Chart 3:** PRWE year 1 status by fracture AO-ASIF classification.  
1: 23-aA; 2: 23-A3; 3: 23-B3; 4: 23-C1; 5: 23-C2.

Technically, the MIPO technique's advantage is that it preserves the origin and insertion of the PQ muscle, avoiding damaging the FPL due to a friction mechanism of the volar plate [19,20].

Milan, *et al.* [21] recommend using the MIPO technique in extra articular fractures or selected intra articular fractures. They mention that the use of Henry's classic approach with extended soft tissue and PQ dissection decreases vascularization and increases the risk of postoperative infection.

Some studies mention that preservation of the square pronator muscle or post-operative reconstruction reduces pain during recovery [22].

We would like to highlight certain aspects derived from the statistical analysis:

There was a statistically significant relationship between the complexity of the fracture, determined by the AO-ASIF classification used and the surgical time, the greater complexity of the fracture the longer duration of the surgery. However, during the 5 years period the surgical time decrease from 86.3 to 59.5 minutes could be motivated by the accumulation of experience, learning increase and new skills by the operating room staff, especially surgeons, by the incorporation of new trained personnel and by a more refined mastery of the routines used in the intervention procedure.

The variables age and sex of the patient did not significantly influence the duration of the surgery.

The average surgery time was 72 minutes, with an average of 58.3 in 23-A2 fractures and 93.7 in 23-C2 fractures, Liverneux [15] reports an average of 43 min for type A fractures and an average of 55 minutes for type C fractures, Bing Zhang, *et al.* report less 95 mins and more 95 mins with Henry's classic approach in his paper, without further details of surgical time [2], Goo Hyun Baek, *et al.* reported averages of 59 +/- 19 min with the classic approach and 49 +/- 17 min using an external fixator [23]. The duration of the surgery is seen to decrease significantly during the 5 years of the study so it could be stated that it is certainly a matter of learning curve.

Regarding the PRWE, there is a statistically significant decrease, year after year (2015 - 2019) in both the third week and one year follow up, the decrease of the third week examination being more related to the quality of the surgical procedure, on the other hand the one year examination decrease was related to other additional variables that were not evaluated in this study, as could be the ones described by Scott W. Wolfe *et al.* - sociodemographic, physiologic and psychological [24], this significant decline in PRWE is also seen in the paper written by Walenkamp MMJ, *et al* [25].

Sex did not have any significant statistic relation with the PRWE values.

Contrary to my initial hypothesis, it was demonstrated that the PRWE values are not directly related to the severity of the fracture. The decreases in the PRWE scores between the beginning and the end of this 5 years study are enormous i.e. there was not a significant difference between the PRWE scores of the 23-A2 fractures and the 23-C2 fractures, the PRWE values decreased (improvement) constantly from the three weeks examination to one year examination and also showed a constant decrease (improvement) during the five years period.

With the arrival of arthroscopic assistance in distal radius fractures it is very likely that the indications and use of the MIPO technique will increase significantly.

In certain fractures the MIPO technique must always be considered, being very important to recognize that as any learning curve it must start with fractures of little complexity and gradually give way to its application in more technically demanding fractures.

The main idea of this paper is to make known the experience using this technique in my hospital, and to show the results and variables that I found relevant.

In the future, it would be ideal to compare these results with those obtained with other techniques or even to formulate more hypotheses or surgical protocols for the improvement of the surgical management of this type of injury.

One of the limitations of this study is the short duration of the follow up and the lack of comparison with other techniques.

Future studies would be helpful to validate these results.

## Bibliography

1. Chung KC, *et al.* "The frequency and epidemiology of hand and forearm fractures in the United States". *The Journal of Hand Surgery* 26.5 (2001): 908-915.
2. Yanse Li, *et al.* "Incidence of complications and secondary procedure following distal radius fractures treated by volar locking plate (VLP)". *Journal of Orthopaedic Surgery and Research* 14.295 (2019): 1-9.
3. Mattila VM, *et al.* "Significant change in the surgical treatment of distal radius fractures: a nationwide study between 1998



- and 2008 in Finland". *The Journal of Trauma* 71.4 (2011): 939-943.
4. Vernet P., *et al.* "Minimally invasive anterior plate osteosynthesis of the distal radius: A 710 case-series". *Orthopaedics and amp; Traumatology, Surgery and amp; Research: OTSR* 106.8 (2020): 1619-1625.
  5. Igeta Y., *et al.* "The minimally invasive flexor carpi radialis approach: a new perspective for distal radius fractures". *European Journal of Orthopaedic Surgery and amp; Traumatology: Orthopedie Traumatologie* 28.8 (2018): 1515-1522.
  6. Imatani J., *et al.* "Minimally invasive plate osteosynthesis for comminuted fractures of the metaphysis of the radius". *Journal of Hand Surgery* 30.2 (2005): 220-225.
  7. Wei XM., *et al.* "Minimally invasive plate osteosynthesis for distal radius fractures". *Indian journal of Orthopaedics* 48.1 (2014): 20-24.
  8. Asmar G., *et al.* "Surgical comfort and clinical outcomes of MIPO with an extra-short plate designed for distal radius fractures". *European Journal of Orthopaedic Surgery and amp; Traumatology: Orthopedietraumatologie* (2020).
  9. Zemirline A., *et al.* "Minimally Invasive Plate Osteosynthesis surgery of distal Radius Fracture: a series of 20 cases using a 15mm anterior approach and arthroscopy". *Chirurgie de la Main* 33.4 (2014): 263-271.
  10. P Liverneaux., *et al.* "Outcomes of minimally invasive plate osteosynthesis with volar locking plates in distal radius fracture: are view". *Hand Surgery and Rehabilitation* 35S (2016): S80-85.
  11. Zenke., *et al.* "Clinical results of volar locking plate for distal radius fractures: convectional Vs MIPO". *Journal of Orthopaedic Trauma* 25 (2011): 425-431.
  12. Wei., *et al.* "Minimally Invasive Plate Osteosynthesis for distal radius fracture with long segment metadiaphyseal comminution". *Orthopaedics and Traumatology: Surgery and Research* 102 (2016): 333-338.
  13. Senthil Kumar., *et al.* "Functional outcome of distal radius fracture managed by minimally invasive plate osteosynthesis: a prospective study". *International Journal of Scientific Study* 4.7 (2016): 161-164.
  14. Jesse Jupiter., *et al.* "AO Distal radius fracture classification: global perspective on observer agreement". *Journal of Wrist Surgery* 6 (2017): 46-53.
  15. Livernaux Philippe. "The minimally invasive approach for distal radius fractures and malunions". *JHS (E)* (2017): 1-10.
  16. Ji F., *et al.* "Minimally invasive percutaneous plate osteosynthesis (MIPPO) technique applied in the treatment of humeral shaft distal fractures through a lateral approach". *International Orthopaedics* 33 (2009): 543-547.
  17. X Wei., *et al.* "MIPPO for distal radius fracture with long segmental diaphyseal comminution". *Orthopaedic and Traumatology Surgery and Research* 102 (2016): 333-338.
  18. Ghada Asmar., *et al.* "Surgical comfort and clinical outcomes of MIPO with and extra-short plate designed for distal radius fractures". *European Journal of Orthopedic Surgery and Traumatology* (2020).
  19. Adam J Mirarchi., *et al.* "Minimal invasive surgery: Is there a role in distal radius management?" *Current Reviews in Musculoskeletal Medicine* (2021).
  20. Saeed Asodollahi and Prue P A Keith. "Flexor tendon injuries following played fixation of distal radius fracture: a systematic review of the literature". *Journal of Orthopaedics and Traumatology* 14.4 (2013): 227-234.
  21. Sen MK., *et al.* "Minimally invasive plate osteosynthesis of distal radius fractures using a pronator sparing approach". *Techniques in Hand and Upper Extremity Surgery* 12 (2008): 2-6.
  22. Häberle S., *et al.* "Pronator quadratus repair after volar plating of distal radius fractures or not? Results of a prospective randomized trial". *European Journal of Medical Research* 20 (2015): 93.
  23. Young Hak Roh., *et al.* "A randomized comparison of volar plate and external fixation for intra-articular distal radius fractures". *The Journal of Hand Surgery American* 40 (2015): 34-41.

24. Scott Wolfe., *et al.* "A unified approach to outcomes assessment for distal radius fractures". *The Journal of Hand Surgery American* 41.4 (2016): 565-573.
25. Walenkamp MMJ., *et al.* "Surgical versus conservative treatment in patients with type A distal radius fractures, a randomized controlled trial". *BMC Musculoskeletal Disorders* (2014): 15-90.