



A Non-Invasive Method for the Treatment of the Distal Radius Fractures

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Summary

The distal radius fracture is a frequent injury in old persons. His treatment remains critical because of number of cases, the final cost of the procedure, the level of X-rays irradiation and a demanding technic of fixation in osteoporotic bone. An entire closed procedure is possible using a percutaneous nail like in lower limbs. This offers advantages in terms of postoperative pain, per-operative irradiation and cost. The main problem was so far the ability to insure a stable reduction in time in those osteoporotic bones. This point is discussed with the introduction of the new "Nail-o-flex®" nail. A continuous series of 83 patients is introduced.

Introduction

The fracture of the distal radius is very common [1] and even the third most frequent among seniors (15% of the fractures amongst the elderly). It is estimated that 150,000 people sustain a distal radius fracture every year in France [2]. The simplicity, the efficiency and the low cost of the surgical procedure are decisive factors in terms of public health. Therefore, their mechanism should better be fully understood [3-5]. The challenge in those distal radius fractures is to restore an appropriate reduction when the cancellous bone has been dramatically collapsed. The challenge is to treat a bone void without any opening of the fracture site. The use of a percutaneous nail seems to gain, year after year, an important place in the treatment of that distal radius collapse, probably by its particular ability to restore and maintain the radial length. The radius is a long, relatively straight bone, and frequently subject to fractures because of its protective role in the event of a fall or accident. The long wires were used from the first World War. The flexible pins were described as early as the 1950s. Several types of flexible nails dedicated to distal fractures appeared in the early 2000s. Today, there are specifically designed wires for fractures of the radial diaphysis.

Material

The compaction chamber

During a fall, the wrist undergoes a force of compression and flexion which causes a crush of the bony trabecular structure of the distal radius. The cortical break comes along with the flattening of the deep cancellous bone. The first principle of a closed nailing is to recognize the existence of a "compaction chamber", that is to say a void of bone. The aim is to open this compacted area and keep its banks well apart to restore the length of the bone. The elasticity of the nail has to enable to maintain this opening. This principle was described by Desmanet in 1989 [6], 30 years ago. On the other side, some implants have even been specially designed to fill directly the void of this compaction chamber (Figure 1).

Those expandable devices have the disadvantage of being bulky and not providing any mechanical stability. However, they widely open the fracture focus and they offer the advantage of showing the volume of bone loss at the distal metaphysis level. The bone loss is considerable as showed above. It explains why those kinds of fractures are difficult to treat in time.



Figure 1: Implant expansible Conventus DRS®

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First Stage Gently Pull Out the Wrist and Reopen the Fracture Site

The fracture of the distal radius is reduced by manual traction. It disimpacts the fracture site and reopens the metaphysis. The nail, as a central stake, maintains the length and the void of the fracture place. The aim of a percutaneous nailing is to restore the radius length and to reduce properly the distal radio-ulnar joint. The major point is to keep the bone aligned by the help of a stable intramedullary distractor. A locking device of the distal extremity is absolutely necessary in order to perform a stable alignment (static nailing). A simple nailing would result in a secondary collapse of the radius (Figure 2,3,4).

Nailing History

The nailing of long bones was described by R. Danis of the University of Brussels (Belgium) in 1938 and by G. Küntscher at the University of Kiel (Germany) in 1939 [7]. The later used his nails on the wounded of the Finnish front during the Second World War [8]. The transverse locking of the nail has been described by Modny and Bambara in 1953 [9]. This lock was improved by Kempf and Grosse [10] in 1978 to the point where it prevailed over the screw plate osteosynthesis which was very popular in the 1960-1980 (Figure 5).

This method of treatment has revolutionized the surgery of femur or tibia. Since the year 2000, it has been applied to the upper limb by drawing smaller, miniaturized nails as it were. The goal was to go back to closed-focus osteosynthesis, as done for the lower limbs. Most recent series seem to show the equivalence of radiological and functional results, between closed nailing and the anterior plates. Grad & Milka say in 2014, into "Injury" Orthopedic Journal that: "The present study supports the view that intramedullary nail fixation and flat fixation for the treatment of displaced extra-articular distal radius fractures have equivalent radiographic and functional outcomes" [11].

Second stage

How to use the Nail-o-flex® nail? The "S" shape need to gently turn 180° when introducing it (Figure 6). The Nail-o-flex® nail was introduced in 2005. It is a specific nail for fractures of the distal radius. It comprises a distal portion which is perforated and a long, smooth proximal part that is thin and flexible to ensure elasticity. The "Nail-o-flex"® nail application technique is directly derived from the long bones nailing of the lower limb.

The radius fracture is reduced by manual traction. The nail is inserted at the level of the snuffbox, outside the tendinous areas. The entrance is perforated with a small square point. The nail has an "S" shape. It is inserted with curvature upside down to fit the metaphyseal angle, it is then turned over and entirely inserted. It is stopped by

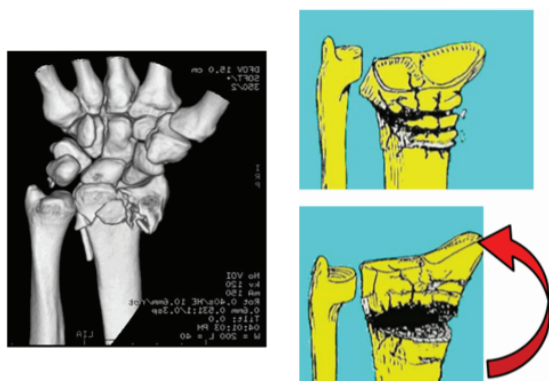


Figure 2: Reopening of the fracture site

Description: Fracture of the distal radius with the crushing of the metaphyseal bone. The aim is to maintain it open.



Figure 3: The reduction of the fracture

Description: The reduction of the fracture opens the compaction chamber which collapse is opposed by the elastic reaction of the nail. The self-stability is ensured by an "S" design with 3 fix points

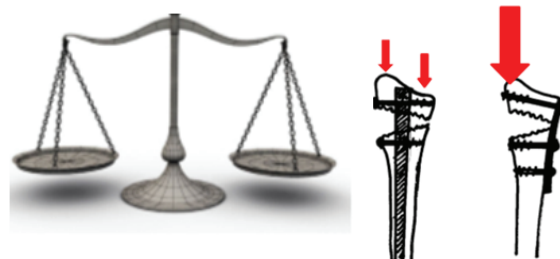


Figure 4: Moment of the compressive force exerted on the locking screw of the nail and the palmar plate

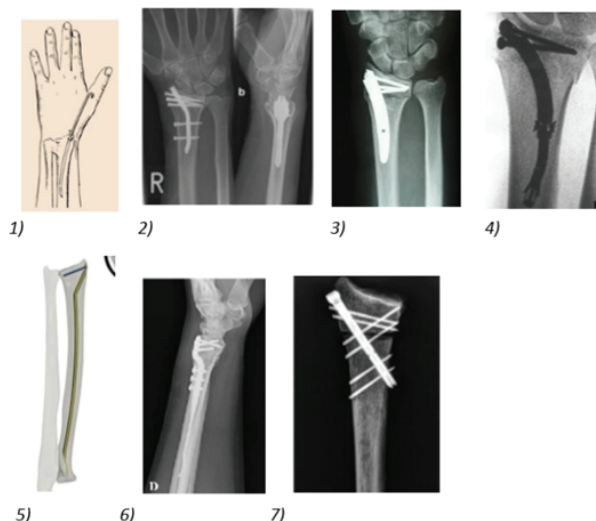


Figure 5: Different nails for the distal radius fractures 1) Rusch nail (1955) 2) "targon"® nail, 3) "micro-nail"® 4) "Sonoma"® nail 5) "Rin"® nail 6) "DNP"® dorsal nail-plate 7) Zimmer "X-Screw"® locked screw

the aiming frame which stumbles on the radial styloid. Locking is performed as for the femur or tibia. The nail is freestanding thanks to its "S" design and its 3 points of support. It is also elastic since the 2/3

of the nail is fine as a pin (2mm) and automatically realigns the distal epiphysis and keeps the focus open. It must be locked at its. Distal part, with at least two epiphyseal screws (Figure 7).

Method

Between May 2008 and May 2015, the Nail-o-flex® nail was used to treat fractures of the lower end of the radius. All cases presented an extraarticular fracture (Colles or Smith) or intra-articular ones (except marginal fracture and comminuted fractures with 4 fragments or more). The preliminary series includes 83 cases.

Of these 83 cases, the female/male ratio was 7 to 1. The average age was 63 years, ranging from 18 to 89 years. Average operating time was 45 minutes. The hospital stay was 2 days up to 2013, when all these fractures were then treated as outpatients. A Velcro splint has been routinely used for a period of 5 weeks. The clinical results were analyzed with the Constant score: 55 excellent, 20 satisfactory and 8 poor result. There was no redo for insufficient result. Fractures have been classified according to the French "Laulan and Bismuth" [11] classification.

The purpose of this Clinical Series was to confirm that metaphyseal bone defect could be treated with an elastic nail according to the principle of Desmanet, without graft or surrogate, and that the distal epiphyseal lock was sufficient to keep the epiphyseal fragments in a

good position during the entire consolidation period. In this series, we have shown that 75/83 cases had retained a radio-ulnar index less than or equal to 0. This shows a good restoration of the length of the radius. These cases correspond to the 75 cases excellent and good cases of the pre-series. (See results at the end of the paper).

Discussion

BY now, the nailing of the fractures of the radius is considered as an outsider because there is a kind of unanimity about the anterior screwed plate. One can criticize plates to be inserted openly opposite to the damaged area (Figure n° 4). This method is mechanically critical. This can also be the source of additional pain. However mini-nails of the radius have been compromised by unreliability and limited indications. None of them had incorporated the need for an elastic recall force to oppose the natural compaction of the compaction chamber. This is the originality of the nail-oflex® nail.

The nail-o-flex® nail is something like a "nail-pin" device. It combines a distal stable locked part according to Kempf and Grosse and a proximal elasticity extremity according to Desmanet. As so, it can behave like an internal distractor. Improvements have been made on the quality of the locking screws and the accuracy of the viewfinder. Today this nail is a simple to use for any operator familiar with the femur or tibia nails.

The compaction chamber

The first question in the distal radius fractures seems the loss of bone matter in the metaphyseal region due to the flattening of the spongy bone. The clinical series has shown that the radius only recoils in 6% of cases (78/83), whereas this complication was frequent with the Kapandji type entanglements. Efficiency seems to be due to the fact that the nail acts as a central guardian, without shear stress.

The reduction is stable in time

Secondarily, to maintain a quality epiphyseal, an accurate reduction is necessary. The use of palmar plates may seem paradoxical since the bone comminution is mainly on the opposite side [12,13]. The operator does not have access to it. Even self-stable screws cannot replace a missing bone. Many authors question themselves about this method which is widely diffused [13-15]. The intramedullary percutaneous nail is mechanically more logical [16,17]. It is central, thus more neutral and simple to use. Lateral approach is direct and offers more security.

Stable reduction and functional results

To maintain a good orientation of the radial epiphysis: The functional result is good if the 15° epiphyseal anteversion is restored. One tolerates a tilting of only a few degrees because it does not have any impact on the degree of flexion of the wrist. But a retroversion of the epiphysis was considered a poor result, even if the index radio-ulnar remained equal to zero. We found 7 poor cases, mainly at the beginning of the series. However, the absence of shortening of the radius made it possible to maintain normal pronosupination. Patients therefore did not feel the need for a redo.

Pain control

The painful assessment is favorable. It is recognized that closed osteosynthesis are less painful than open procedures as screwed plates [18]. This was notified by Kempf and Gross in the 1970, in lower limbs fractures.

Aesthetics

The aesthetic aspect is interesting. The intervention is conducted by 3 or 4 holes of 2 or 3 mm (Figure 8).

Final cost

And its cost is low: the implant and screws cost is around 450 euros. Implant cost is voluntarily low.

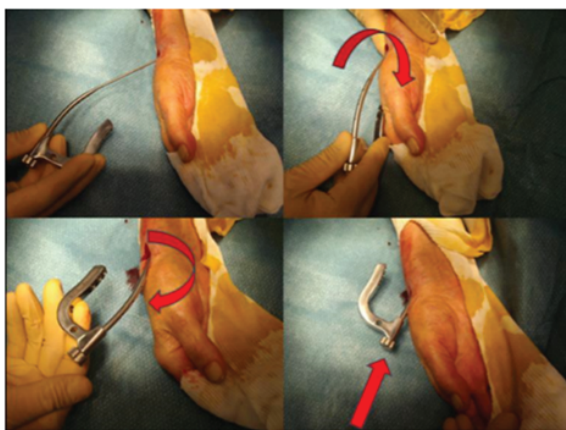


Figure 6: Introduction of the Nail

Description: The nail is introduced in reversed position. It is turned 180° as long as pushed forwards. A "clic" is heard by the time the fracture is reduced

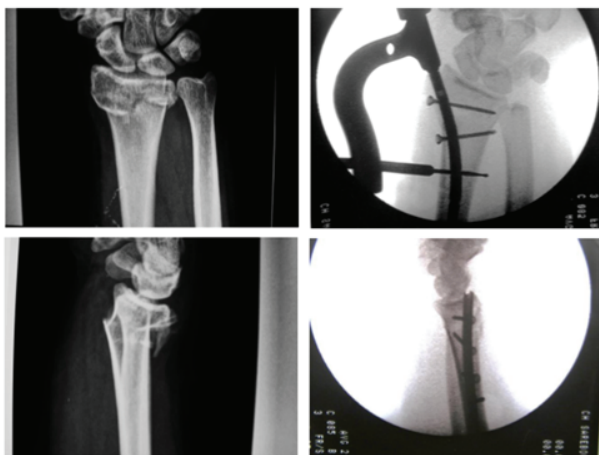


Figure 7: Radiological aspect of the reduction and nailing of a distal radius fracture



Figure 8: Operative aspect: 3 to 4 skin sutures

Laulan and Bismuth classification [12] (Figure 9)



Figure 9: Laulan and Bismuth classification.

Description: A simple and predictive analysis grading the metaphyseal rupture, the epiphyseal comminution and the distal ulna break

Result of the Clinical Series (2008-2017) (Table 1)

	Laulan & Bismuth class	DRU	Anteversion	Functional Result
1	M4 E3 C1	-1	0	excellent
2	M4 E3 C0	-2	-10	good
3	M4 E4 C1	0	-5	good
4	M4 E2 C0	0	5	excellent
5	M4 E3 C1	0	5	excellent
6	M4 E3 C1	0	0	excellent
7	M4 E2 C0	-2	10	excellent
8	M4 E4 C1	-2	-5	good
9	M4 E3 C1	0	-12	poor
10	M4 E3 C0	-2	10	excellent
11	M4 E3 C0	-2	10	excellent
12	M4 E4 C0	0	-15	poor
13	M4 E3 C1	-2	5	excellent
14	M4 E2 C0	0	0	excellent
15	M4 E3 C0	-2	10	good
16	M4 E2 C2	0	10	excellent

17	M4 E4 C1	2	-5	excellent.
18	M4 E4 C1	0	-5	good
19	M4 E3 C1	0	-10	good
20	M4 E4 C2	0	10	excellent
21	M4 E3 C0	2	0	excellent.
22	M4 E3 C2	0	5	excellent
23	M4 E2 C0	2	-15	poor
24	M4 E2 C0	-2	0	excellent
25	M4 E3 C0	0	0	excellent
26	M4 E3 C0	0	0	excellent
27	M4 E3 C1	0	0	good
28	M4 E3 C0	0	10	excellent
29	M4 E3 C1	-2	0	excellent
30	M4 E3 C0	0	0	excellent
31	M4 E4 C1	-2	10	excellent
32	M4 E4 C1	0	0	good
33	M4 E3 C1	-3	10	excellent
34	M4 E3 C1	0	0	excellent
35	M4 E3 C0	0	0	excellent
36	M4 E3 C1	-2	0	good
37	M4 E2 C1	0	-10	poor
38	M4 E4 C2	0	0	excellent
39	M4 E2 C1	0	0	good
40	M4 E2 C1	0	-15	poor
41	M4 E4 C1	-2	0	excellent
42	M4 E3 C2	0	0	good
43	M4 E4 C0	-2	10	excellent
44	M4 E3 C1	-2	0	excellent
45	M4 E3 C0 Smith	0	0	excellent
46	M4 E2 C1	-2	0	excellent
47	M4 E2 C0	-2	-10	good
48	M4 E3 C0	2	-10	poor.
49	M4 E3 C1	0	5	excellent
50	M4 E2 C0	-2	10	excellent
51	M3 E4 C0 Smith	0	15	excellent
52	M4 E4 C0	-2	10	good
53	M4 E3 C0	0	0	excellent
54	M4 E2 C1	-2	5	excellent
55	M4 E4 C0	-2	0	excellent
56	M4 E2 C0	0	0	good
57	M4 E3 C0	-2	5	excellent
58	M4 E2 C0	0	0	good
59	M4 E2 C1	2	0	excellent.
60	M4 E3 C0	-2	5	excellent
61	M4 E3 C1	0	0	excellent
62	M4 E3 C0	-2	10	excellent
63	M4 E4 C1	0	5	good
64	M4 E3 C0	-2	10	excellent
65	M4 E2 C0	-2	0	excellent
66	M4 E3 C0	-2	0	excellent
67	M4 E4 C2	2	-10	poor
68	M4 E3 C0	-2	0	good
69	M4 E4 C1	-2	5	excellent
70	M4 E4 C1	-2	5	excellent
71	M4 E3 C4	0	0	good
72	M4 E3 C0	-2	5	excellent
73	M4 E3 C0	0	0	excellent
74	M4 E3 C1	0	0	good
75	M4 E3 C0	0	5	good
76	M4 E3 C1	-2	5	excellent
77	M4 E2 C2	0	0	excellent
78	M4 E2 C1	0	10	excellent
79	M4 E3 C0	-1	10	excellent
80	M4 E3 C0	3	-10	poor
81	4 E3 C0	-1	10	excellent
82	M4 E3 C0	-2	5	excellent

Functional results: Excellent = 55

Good = 20

Poor = 8

Table 1 : Clinical series: A continuous series of 83 cases of distal radius fractures treated with percutaneous nailing "Nail-o-flex®"

Conclusion

Distal radius pinning is proving itself to be logical and reliable. The "Nail-o- Flex"® nail was designed in 2005. Its aim was to offer an immediate stability along the radial shaft with an effective grip on the proximal diaphysis (3 support points). This seems to offer indeed a stable length restoration of the radius bone. With its 12 years of success records, the nail is a simple and inexpensive osteosynthesis implant. Its use is easy for any surgeon familiar with the pinning of the tibia. Its reliability is comparable to the best series of palmar plates. It requires only moderated X-ray irradiation.

Conflict of Interest

The author of this article is the designer of the NOF nail. The present article regards a continuous and monocentric series of 83 patients treated by a nailing of their distal radius fracture. All the cases were operated by the designer and performer. The present article, and clinical review, is not sponsored by any company.

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