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A PROSPECTIVE STUDY ON THE MANAGEMENT OF DISTAL RADIUS FRACTURES BOTH INTRA AND EXTRA ARTICULAR BY OPERATIVE ANDNON- OPERATIVE TECHNIQUES

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ABSTRACT

This study is conducted to analyse the specific treatment options in both extra and intra-articular distal radius fractures by classifying the subjects into three groups depending on the fracture morphology.The distal radius fractures can be treated with good to excellent outcomes irrespective of the fracture patterns if the treatment option is carefully planned. Pre-operative treatment planning and post-operative rehabilitation protocol play very important role in outcome.

Keywords
intra-articular fracture morphology, rehabilitation, lunate fossa , distal fragment, radiological outcome

INTRODUCTION

The most common among the upper extremity fractures presenting to the emergency room are the distal radius fractures. Statistically they account for 20% of all the fractures[57] . With their bimodal age distribution distal radius fractures in the younger population are seen more in males sustaining high energy trauma, while older females usually give history of fall on an out stretched hand. Females with higher life expectancy than males and are prone to osteoporosis[1] . Therefore, the distal radius fractures are encountered more in females[2] Six decades ago, without the knowledge of different techniques of treatment, these fractures were treated conservatively. However, the knowledge of correcting the intra-articular step-off, inclination, shortening and radial height have led to a satisfactory outcome in patients[3 , 4]. The demography leaning toward the older age, healthy lifestyle and productivity has inclined most of the eld erly population to opt for surgical treatment for distal radius fractures. The goal of this treatment is to restore the range of movement of wrist[3 , 4] .

Stable reducible and minimally displaced fractures both intra and extra-articular fractures can be treated conservatively. Extra-articular fractures which are unstable can be reduced and stabilized using percutaneous pins. In cases of unreducible extra-articular fractures or comminuted intra-articular fractures, external fixation or open reduction with internal fixation using pins or planting are the available options[5 , 6 , 7 , 8] .Earlier when the distal radius fractures were treated conservatively by closed reduction and cast immobilization, fractures which were comminuted and had intra-articular step-off showed malunion, stiffness in wrist and hand, dislocation of distal radio-ulnar joint resulting in poor functional and radiological outcome[9] .

With these complications patients complained of decreased wrist motion and hand functionality, hindering the mechanical advantage of the muscles in hand[10] . On prolong duration, these complications caused pain, limited motion in forearm and loss of the grip strength in hand [11] .pen reduction internal fixation using volar plating has shown to provide an adequate correction of displacement with maintaining the reduction. If the distal radius fractures are

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presented late or if there is a metaphyseal defect, they can be filled with bone grafting. But in case of fresh fractures and good bone quality this option is eliminated[12] .

MATERIALS AND METHODS

The study is a prospective study conducted at Sree Balaji Medical college and Hospital from July 2017 to December 2018. This study included distal radius fractures both intra and extra-articular. These fractures were classified based on Frykman classification for distal radius fractures. Based on the type of fracture the management was either conservative with slab/cast with/without K-wire augmentation or external fixation or with ORIF using a volar plating.

Inclusion criteria:

1. Age group 20-60 years
2. Only patients with fresh fractures (i.e within a week from injury)
3. Frykman type 1 to 8 Closed fractures
4. Follow-up of minimum 6 months

Exclusion criteria:

1. Pathological fractures
2. Fractures occurring in metabolic challenged bones
3. Previous ipsilateral or contralateral fracture of wrist
4. Patients with severe co-morbidities
5. Patients with psychiatric illness

Patients were evaluated using multiple X-rays to define the type of fractures. The fractures with intra - articular extension were further evaluated using CT with 3D reconstruction when required to plan the fixation. Extra- articular fractures which were conformed to be Frykman type 1 and 2 were treated conservatively. The Frykman type 2 -8 is used to classify the intra- articular fractures. Closed intra-articular fractures alone were included in the study. Based on these fracture types subjects were classified into three groups.Group A – Frykman type 1 and 2 with/without comminution Group B – Frykman type 3-8 with/without minimal comminution Group C – Frykman type 3-8 with severe comminution.In our study, we have defined severe comminution when a fracture has more than two distal fracture fragments.

Following conditions were evaluated on presentation of the patient:

1. Skin over the fracture site
2. Neurological status
3. Condition of vascularity
4. Functions of the tendons
5. Movements of the shoulder, elbow and fingers
6. General medical condition

Pre-operative radiological assessment:

Pre-operative routine radiograph of the injured wrist both in antero-posterior and lateral views were taken. Following points were evaluated in the plain radiographs:

1. Radial length
2. Dorsal angulation
3. Radial inclination

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4. Ulnar variance
5. Dorsal comminution
6. Intra-articular extension

Patient Evaluation:
On arriving in the emergency department, detailed history was taken. Consent to examine the patient and further radiological evaluation was done. Patients were placed on the below elbow slab after examination and clinically confirming that patient may have distal radius fracture. Co-morbidities if any were recorded. Patients were further evaluated by concerned departments before being taken up for surgery. Computed tomography was done on the patients if necessary while planning treatment with comminuted intra-articular fractures.

Bridging External Fixator :
The bridging external fixator works on the principle of ligamentotaxis as it provides and maintains reduction in managing distal radius fractures. The longitudinal traction when applied at the carpus there is a tension which is transmitted through the radio-scapulo-capitate and radio-lunate ligaments. When the carpus is pronated the supination deformity which is present in the distal fragment is indirectly corrected.
The rigidity of the distraction frame controls and continues the fracture distraction and fixation of the fracture over short term. The above parameters will be determined by the diameter of the rod, placement of 2 nd parallel rod and placement of 1 st rod close to skin. The fracture fixation can be enhanced by the percutaneous placement of the K-wires. With this technique the radial styloid is locked and provides support to the lunate fossa fragment. By this method we get the advantage of maintaining the radial length and improved range of motion of the wrist when it is compared to four-point fixation alone. The dorsal tilt is corrected by the dorsal pin attached to the sidebar. When a K-wire of 1.5mm is applied it provides a construct which approaches the strength of 3.5mm AO plate.

TechniqueOfJointSpanningExternal Fixator:
Two pins are placed on the proximal and distal part of the 2nd metacarpal. The distal pin is placed 3mm proximal to the transition of the metacarpal head in the shaft. The proximal pin is placed in the shaft 3mm distal to the transition of the shaft in the metacarpal base. The 2nd metacarpophalangeal joint is flexed passively to 90 o so that the extensor tendon is shifted ulnarly.

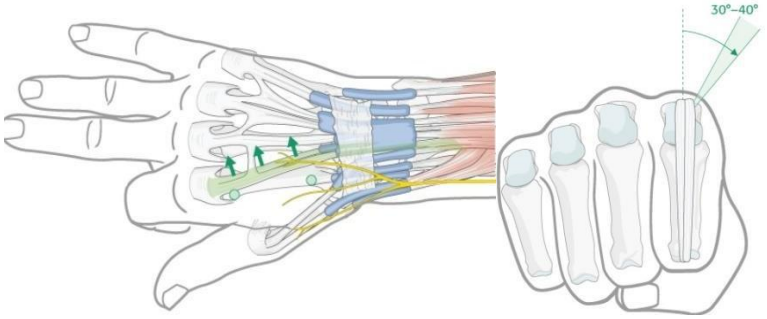

Fig No: 30 Technique of Metacarpal Pin Insertion

An incision is placed distally to the muscle bellies of the abductor pollicis longus and extensor pollicis brevis. The incision is used for blunt dissection to reach the bone surface and no

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neurovascular structures are to be injured. Two pins are to be used in a plane which is transverse and lies at an angle 450 to the frontal and 450 to the sagittal plane.
As the ligaments are visco-elastic gradually over period of time the distraction of the fragments with correction of the radial height, inclination, tilt and reduction may be lost especially if there is a displaced intra-articular fragment. Complications such as pin tract infection, loosening, injury to the extensor tendons and superficial radial nerve injury can be noticed post- operatively.

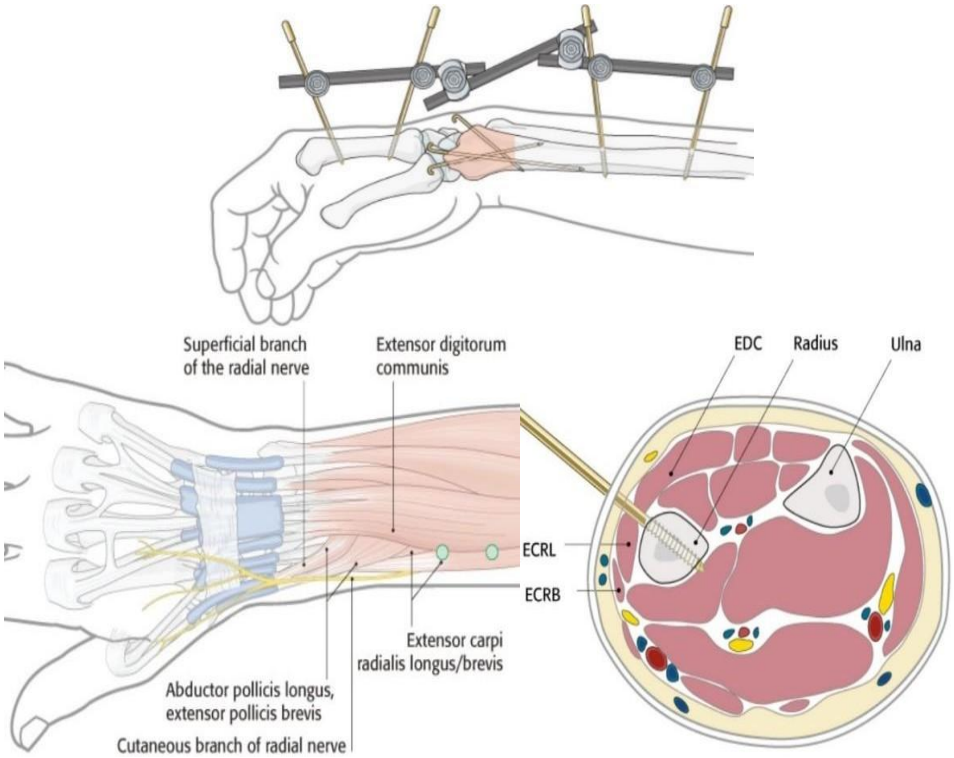

Fig No: 31 Insertion of the K-wires to augment the external fixation construct

In our study a successful reduction was defined as:
1. Step deformity of 2mm or less than 2 mm
2. Nil dorsal tilt
3. Less than 5mm of radial shortening.

Post-Operative Evaluation:
Functional and radiological evaluation of the patients were carried out in the study at 3 months, 6 months and 12 months. A maximum of 18 months of follow-up is recorded in our study. The subjects to include in the study ends on June 2019 and the study concludes in December 2019. Therefore, the functional and radiological evaluation of all the patients when grouped and evaluated shall be for a duration of 6 months in this study.

Post-Operative Radiological Evaluation:
X-rays of the wrist in standard antero-posterior, lateral and 22 degree cephalad view were taken in the evaluation post-operatively. The radial height, radial inclination, residual deformity if any and palmar tilt were recorded. Residual deformity is defines as having prominent ulnar styloid,

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residual dorsal tilt and radial elevation of hand. The radiological evaluation was analysed using Sarmiento's modification of Lindstorm criteria.

Result	Residual Deformity	Loss of radial tilt(0)	RadialShortening (mm)	Loss of Radialdeviation(0)
Excellent	Nodeformity/ insignificant	0	<3	5
Good	Slight	1-10	3-6	5-9
Fair	Moderate	11-14	7-11	10-14
Poor	Severe	Atleast 15	>=12	>14

Tableno:2Sarmiento'smodificationofLindstorm criteria

Pre-Operative Planning:
Depending upon the fracture type, stability and quality of the bone the patients were divided into three groups. Patients confirmed to have extra-articular fracture which are undisplaced or minimally displaced that remain stable after closed reduction and in low demand patients the cast immobilization was the treatment of choice. If the fractures were not reducible to satisfactory radiological parameters, the fractures were fixed using 1.5mm K -wire under regional block and image intensifier. When the fractures were confirmed to be intra-articular with minimal comminution with intra-articular step >2mm, the fractures were fixed using volar LCP. When the fractures were confirmed to be have more than two distal comminuted fragments, these fractures were managed with the help of external fixator on the principle of ligamentotaxis.

Closed Reduction And Immobilisation- Group A Patients:
Most of the patients in our study had a history of road traffic accident and few had history of fall on an out stretched hand. Patients were examined and routine X-rays were taken and evaluated. Patients confirmed to have extra - articular fracture which are undisplaced or minimally displaced that remain stable after closed reduction and in low demand patients, gentle traction with ulnar deviation at the wrist is maintained to reduce the fracture. In fractures where closed reduction was not radiologically acceptable, these fractures were reduced using 1.5mm K-wire under regional anaesthesia with the help of image intensifier.

Patient Positioning-Group B And C Patients:
Patient in supine position with parts painted and draped. The injured upper limb was placed on a radio-lucent table with image intensifier to visualize the wrist joint particularly the distal radius, distal ulna and the articular surface in antero-posterior and lateral views.

Surgical Procedure:
Procedures were performed under regional or general anaesthesia. Interscalene or supraclavicular block was administered in regional anaesthesia. Parenteral antibiotics was administered an hour before the patient was shifted for procedure. Tonique was used in all the patients. Homeostasis was achieved before closure. In supine position under sterile aseptic precautions parts were painted and draped. Forearm was placed on a radiolucent table. C - arm or image intensifier was used in all the procedures to visualise the distal radius fracture and reduction and restoration of the articular surface.

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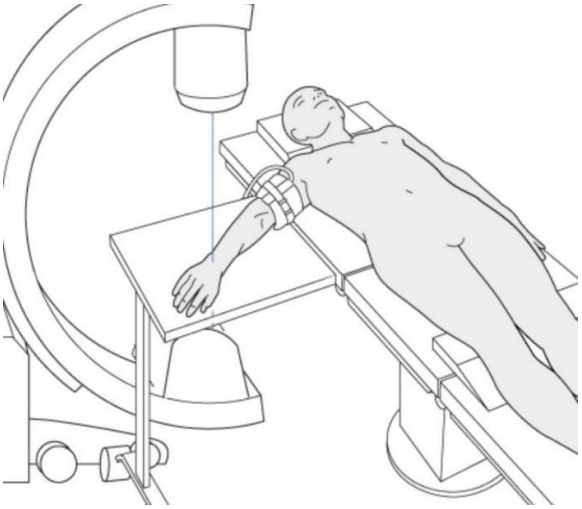

Fig no: 32 procedure performed in patient in supine position with wrist in pronation for closed reduction using joint spanning external fixator.

RESULTS

In Group B : fractures treated using internal fixation was proceeded using modified Henry's approach was used. In patients were external fixation was planned Kirschner wires were used with screws. With the help of image intensifier K-wires of 1.5mm were used to reduce the fracture in case of multifragmentary fragments. Reduction was confirmed under C-arm. A 12-gauge needle was passed into the wrist joint over the distal radial articular surface to prevent distal migration of the plate. Then a volar LCP of 2.4 mm for distal radius was applied with the screws first placed on the distal fragment. Reduction and fixation confirmed under C-arm the K-wire was removed or left in- situ and through wound wash given. Drain was placed in all the patients treated with internal fixation. Wound closed in layers and sterile dressing done. In Group C : Fractures with severe comminution were treated with external fixation. With the help of image intensifier 2 pins were placed on the shaft of the 2 nd metacarpal. The distal pin was placed approximately 3 -5mm proximal to the transition of the metacarpal head. The proximal pin was placed 3 -5mm distal to the transition of the metacarpal base. To avoid injury to the extensor tendon the 2nd metacarpo-phalangeal joint was flexed to 900 and the pins were placed at 300 -400 in relation to the sagittal plane. The tendons of the abductor pollicis longus and extensor pollicis brevis were identified. The radial shaft can be palpated through the skin between the muscle bellies of these two muscles and a small incision was placed radially to visualize the bone and 2 pins were placed 450 to the frontal and sagittal plane. It was made sure that the pins were perpendicular to the transverse section of radius. Additional k-wires were placed to restore the anatomy of the distal radius

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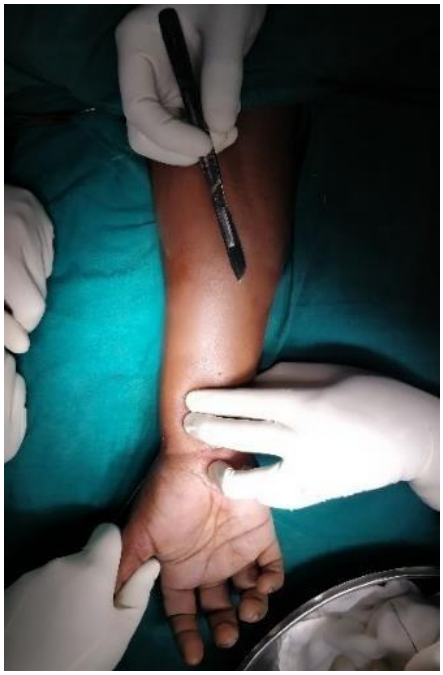

Fig no: 36 palpation of the radial artery before placing the incision

Fig no: 37 incision was placed between flexor carpi radialis tendon and radial artery.

Fig no: 38 the sheath dissected and the tendon wasretracted ulnar ward. K-wire passed through the radial styloid to maintain the reduction.

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Fig no: 39 the incision is deepened to visualize thepronator quadratus. Care must be taken to avoid injury to radial artery. L shaped incision is placed over thepronator quadratus with the base towards the wrist and the long arm on the radial side.

Fig no: 40 shows fracture of the distal radius.

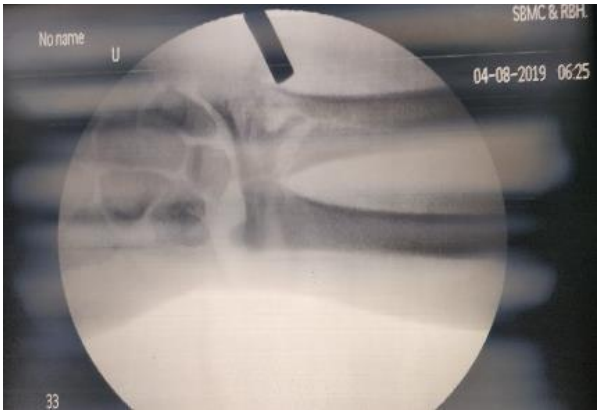

Fig no: 41 C-arm image shows the comminuted distal radius fracture with intra-articular extension.

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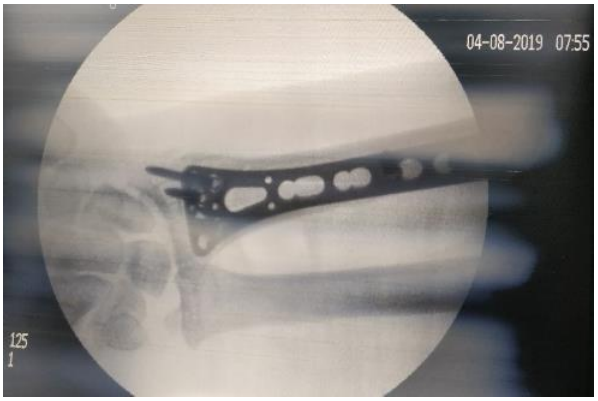

Fig no: 43 shows placement of the 2.4mm bi-columnar volar LCP for internal fixation of the distal radiusfracture.

Post-Reduction Protocol:
Patients treated with close reduction by below elbow slab were converted to cast 1 -week post injury to let the oedema subside. Then cast was continued for another 4 -6 weeks depending on the age, sex and bone quality. On immobilising the patient was encouraged to do active finger movements and keep the limb in elevation when lying supine and to rest the arm in a broad arm sling when ambulating. After confirmation of clinical and radiological union the patient was encouraged to perform active wrist movements but not to weight bear or lift heavy weights on the affected wrist for a duration of at least 3 months post injury.

Post-Op Protocol:
Fractures fixed using external fixation were immobilized for a period of 4 -6 weeks depending on the fracture pattern, age, sex and bone quality. Once the fractures were confirmed to be united clinically and radiologically wrist mobilization is encouraged and patients are advised not to weight bear and lift heavy weights of the affected wrist for a period of at least 3 months post injury.Fractures fixed using open reduction and volar LCP were placed in compression bandage for a period of 1 -week post-surgery and limb elevation using I.V stand was protocol for 3-5 days post operatively. Active finger movements and wrist movements were encouraged from 3 rd day post-surgery. Drain was removed on POD 2 and a regular sterile dressing was done on POD 2,5,8,10 and 15. Sutures were removed on POD 15.

Follow-Up Protocol:
All the patients in the study were followed up once every two weeks for first two months and once a month till six months post-reduction/post-operatively. Functional and radiological evaluation is assessed on every visit of till the maximum follow-up.

Discussion
Distal radius fractures are a common type of fracture Orthopedicians encounter in their everyday practice. Understanding the fracture anatomy will help in planning the treatment options either by operative or non-operative techniques.In our study 30 subjects were males and 27 females. 42 had right distal radius fracture and 15 had left. 19 of them had extra articular fracture and 38 had intra-articular. RTA being the most common mode of injury in our study, accounted for 39 of these subjects. The minimum age of subjects in our study is 21 years and maximum age 59

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years. The higher male to female ratio points towards working men engaging in more physical activity may have increased the incidence of distal radius fractures.

	Minimum age inyears	Maximum age inyears
Jupiter[47] et al (n=117)	16	76
Louis Catalano[40] et al (n=21)	17	42
Anakwe[60] et al (n=21)	19	86
Our study (n=57)	21	59

Table no: 18 comparison of age distributions

	Male %	Female %
Jupiter[47] et al (n=117)	60	40
Louis Catalano[40] et al (n=21)	67	33
John K Bradway[3 1] et al (n=80)	56	44
Our study (n=57)	53	47

Table no: 19 comparison of sex distribution

In our study, 19 subjects were in Group A, diagnosed with Frykman's type 1 and 2 which are extra-articular fractures of distal radius. 68.42% of the fractures had excellent results. 17.64% of the subjects in this group underwent percutaneous pinning under image intensifier. On follow-up, these patients had good functional outcome. They did not have any complaints of pin site infection or loosening. 21.05% had good and 10.52% had fair functional outcome.The 2.4mm volar LCP is a relatively new design with more stable fixation and good to excellent functional and radiological outcome. The more screws placed in the metaphyseal region acting on reefing technique and 5 mm away from the fracture site, these implants have better biomechanical and clinical outcome.

In Group B where the subjects had intra-articular extension with/ without displacement and minimal comminution showed better biochemical integrity of the ligaments which helped the reefing technique. Under anaesthesia, the piano key testing of the wrist had rigid fixation in all of our patients. The mean values of functional and radiological outcome of our study is compared to other studies done on the intra-articular fractures of distal radius where volar LCP and external fixator are used in the fracture treatment. Group B patients with intra-articular extension where there was nil to minimal displacement and minimal comminution showed good to excellent outcomes in all the subjects. The number of the comminuted distal fragments had direct proportion to the complications. Hence, Group C subjects were recorded to have more complications when compared to other two groups. As mentioned by Brandon Broome and Cyril Mauffrey[50] , when treating impacted intra-articular distal radius fractures the anatomic reduction should be the goal of any treatment.

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CONCLUSION

From our study, we conclude that:
The functional and radiological outcomes of the distal radius fractures categorized into three groups based on extra-articular and intra-articular extension with severity of comminution managed with cast immobilization with/without K-wire augmentation, volar LCP and external fixator. Our study is a short-term study with a smaller number of patients, the scope of the study can be increased by large number of patients and long-term follow-up.
Funding: No funding sources
Ethical approval: The study was approved by the Institutional Ethics Committee

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

[1] Winner S. J, Morgan C. A, Evans J. G. Perimenopausal risk of falling and incidence of distal forearm fracture. BMJ, 298:1486 –1488 , 1989.
[2] Owen R. A, Melton L. J, Johnson K. A, Ilstrup D. M, Riggs B. L. Incidence of colles' fracture in a north american community. Am J Public Health, 72:605 – 607, 1982.
[3] Gehrmann SV, Windolf J, Kaufmann RA. Distal radius fracture management in elderly patients: a literature review. J Hand Surg [Am] 2008 Mar;33(3):421 -9.
[4] Young BT, Rayan GM. Outcome following nonoperative treatment of displaced distal radius fractures in low -demand patients older than 60 years. J Hand Surg [Am] 2000 Jan;25 (1):19 -28
[5] Garcia- Elias M, Folgar MA. The management of wrist injuries: an international perspective. Injury 2006 Nov; 37 (11):1049 -56. 80
[6] Shin EK, Jupiter JB. Current concepts in the management of distal radius fractures. Acta Chir Orthop Traumatol Cech 2007 Aug;74(4): 233 - 46.
[7] Keast- Butler O, Schemitsch EH. Biology versus mechanics in the treatment of distal radial fractures. J Orthop Trauma 2008 Sep;22(8 Suppl):S91 -S95.
[8] Fernandez DL. Should anatomic reduction be pursued in distal radial fractures? J Hand Surg [Br] 2000 Dec;25(6):523 - 7.
[9] Bacorn RW, Kurtzke JF: Colles' Fracture: A study of two thousand cases from the New York states Compensation Board. J Bone Joint Surg 1953; 35A: 643 -658
[10] Fernandez DL: Correction of posttraumatic wrist deformity in adults by osteotomy, bone grafting and internal fixation. J Bone Joint Surg 1982;64A:1164 – 1178
[11] Zemel NP: The prevention and treatment of complications from fractures of the distal radius and ulna. Hand Clin. 1987; 3:1 – 11

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 2424 - 2435
Received 15 December 2020; Accepted 05 January 2021.

[12] Brogren E, Petranek M, Atroshi I. Incidence and characteristics of distal radius fractures in a souther n Swedish region. BMC Musculoskelet Disord 2007; 8:48.
[13] Colles A. On the fracture of the carpal extremity of the radius . *Edinburgh Med J 1814; 10:181 -186.*
[14] Pouteau C. Oeuvres posthumes. Ph D Pierres , *Paris 1784, tome second.*
[15] Dupuytren G. On the injuries and diseases of bones, selections from the collected edition of the clinical lectures. *Translation F LeGros Clark, Sydenham Society, London 1847.*
[16] Barton JR. Views and treatment of an important injury of the wrist. *The Medical Examiner 1838; 1: 365 -368.*
[17] Smith RW. A treatise on fractures in the vicinity of joints and on certain forms of accidental and congenital dislocations. *Hodges and Smith, Dublin 1847*
[18] *Jones R (ed)Injuries of joints. London, England, Henry Frowde & Hodder & Stoughon, 1915, p 110*
[19] Connoly J. Fractures and Dislocations. Closed Management.*Philadelphia: WB Saunders, 1995* 88
[20] Anderson R, O'Niel G: Comminuted fractures of the distal end radius. *Surg Gynecol Obstet 1944; 78: 434440*
[21] Charnley J. The mechanics of conservative treatme nt. In: The closed treatment of common fractures. *London: Greenwich Medical Media;2003. p. 43 –59.*
[22] John J.Gartland and Charles W.Werley: Evaluation of healed Colles fracture.- Journal of Bone and Joint Surgery (Am) 1951; 33 : 895 -907.
[23] Castaing J: Recent fractures of the inferior extremity of the radius in the adult (French). *Rev Chir Orthop 50:582696,1964*
[24] Knirk JL, Jupiter JB (1986) Intra- articular fractures of the distal end of the radius in young adults. *J Bone Joint Surg68A(5): 647 – 659*