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A Study on Management of Comminuted Colles Fracture by Closed Reduction and Ulnocarpal Stabilisation with 2 K-Wires

Dr. Addepalli Srinivasa Rao, M.S, M.ch (Ortho), Dr. K.N.Sandeep M.S(Ortho)
Department of Orthopaedics, Siddhartha Medical College, Vijayawada, Andhrapradesh ,India 520008

Abstract
Background – *In comminuted Colles fractures treated by conventional method , malunion during healing due to progressive radial collapse is a common complication. Many modalities of treatment have been described with their merits and demerits. Ulnocarpal stabilization is an effective method to prevent radial collapse and hence this study.*
Materials And Methods – *A prospective study of 100 patients of comminuted Colles fracture between 20-70 years age irrespective of sex treated by closed reduction and percutaneous stabilization of ulnocarpal articulation and above elbow POP cast for 6weeks has been presented. Patients were evaluated at 1 year follow up and functionally by Sarmiento's modification of Lindstrom criteria and Gartland and Werley's criteria.*
Results *– Excellent to good results in 92%,fair in 4% and poor in 4% of total cases. Complications observed were malunion (n=6), pin tract infection (n=7), pullout of k-wire (n=5), sudeck's osteodystrophy (n=7), residual pain (n=4),reduced grip strength (n=8) .*
Conclusion – *Percutaneous pinnng by ulnocarpal stabilization is minimally invasive, yet an effective method to maintain the reduction and stability of distal radioulnar joint and radial collapse during healing ,even when the fracture is grossly comminuted ,intraarticular or unstable .*
Keywords – *comminuted colles fracture, closed reduction, percutaneous pinning, ulnocarpal stabilization.*

I. Introduction

Fractures of the lower end radius constitute 17% of all fractures and 75% of all forearm fractures[1].Closed reduction and POP cast immobilization has been the mainstay of treatment of these fractures, but malunion of fracture and subluxation or dislocation of distal radioulnar joint resulting in poor functional and cosmetic results is the ususal outcome[2].The restoration of the anatomy correlates well with function. The residual deformity of wrist due to malunion of the fractures of the distal end radius and subluxation or dislocation of radioulnar joint which is unsightly and adversely affects the wrist motion and hand function by interfering with the mechanical advantage of the extrinsic hand musculature[3-5].It may cause pain,limitation of forearm motion , and decreased grip strength as a result of arthrosis of radiocarpal and distal radioulnar joints[6-8],incongruity of the distal radioulnar joint[6,9],ulnocarpal impingement[1,10],and carpal malalignment[11].To overcome these, Darrach [12]described the excision of the distal end ulna in cases with disruption of distal radioulnar articulation with or without malunion of distal radius, but results are unpredictable; In many instances, it leads to weakness of grip as well as in stability of the distal end of ulna, and hence there was a need to evolve more aggressive and effective fixation of these fractures. Many treatment modalities have been described with the aim of achieving and maintaining good anatomical and functional end results. Various modalities of treatment available are closed reduction and POP cast immobilization, functional cast bracing ,pin and plaster technique, rush rod fixation, external fixators, percutaneous pin fixation, arthroscopic reduction, open reduction and internal fixation .Each procedure has its own merits and demerits. Closed reduction and cast immobilization[13,14] has been the main stay of treatment ,but collapse of the radius occur even in the face of cast immobilization .

Percutaneous pins to provide additional stability is one of the earliest forms of internal fixation[15-17].Depalma [17]described ulnoradial pinning drilled at 45 º angle,4 cm proximal to ulnar styloid, from ulna into radial styloid.Stein[18] described the use of an additional dorsal pin, an additional 2 –mm pin across the radioulnar joint was also used[19]. Kapandji[20] described double intrafocal pinning (2-mm) into the fracture surface, and Rayhack [21]described ulnaradial pinning with fixation of distal radioulnar joint.

Table 1: Sarmiento's modification of Lindstrom criteria (anatomical evaluation)

	Residual deformity	Loss of palmar Inclination	Residual shortening (mm)	Loss of radial Deviation
Excellent	No/ insignificant	0º	< 3	< 5º
Good	Slight	1 - 10º	3 – 6	5 – 9º
Fair	Moderate	11 – 14 º	7 – 11	10 - 14º
Poor	Severe	At least 15 º	At least 12	>14º

Bridging external fixators and ligamentotaxis indirectly reduce the impacted articular fragments and directly neutralizes the axial laod. Several workers[22,23] reported superior radiographic outcome as compared with cast treatment. Ruch et al[24] ,Schnnur[25], and many others described ORIF of distal end of radius fractures .In gross communition of articular segments ,Bass[26], Rikli et al[27], and others recommend a combination of ORIF ,external fixators , and k-wires to create an intact palmar buttress by using a plate and avert dorsal collapse by tensioning across it using an external fixator. Doi et al[28] recommended arthroscopically guided reduction

The biomechanical study by Graham[29] reported that although the stabilization of distal fibula in ankle injuries play a role , the construct in which ulna is engaged provide superior resistance to fracture displacement with the availability of intact cortical bones, i.e., ulna and carpals. The author thought that the role of stabilization of distal carpoulnar articulation is important in managing comminuted fractures of lower end radius and studied the importance of distal radioulnar joint (DRUJ) and triangular fibro cartilage complex (TFCC) in realigning the anatomy of the wrist joint. The TFCC is the main stabilizer of DRUJ. In Colles fracture ,the breaking of the distal end of radius, with its impaction and dorsal displacement, attenuates this fibrocartilage to maximum degree because of the volar displacement of ulnar head .Considering mainly the cortical nature in these fractures , the present authors emphasized upon closed reduction and stabilization of the ulnocarpal joint ,which indirectly helps to align the fracture fragments (ligamentotaxis) to maintain the radial length ,the articulating surface of distal radius ,realigning the TFCC and DRUJ and also preventing the redisplacement of fracture fragments and collapse during healing, hence this study, where we conducted an analysis of 100 Patients of fracture of lower end radius treated by closed reduction and percutaneous stabilization of distal end of ulna

II. Materials And Methods

This analysis was conducted in 100 patients with comminuted fracture of the lower end of radius who could be followed up from January 2009 to December 2012.Inclusion criteria are that all patients between 20 – 70 years, displaced comminuted fractures, intra/extra articular fractures and fractures of <3 weeks old durartion were included. Exclusion criteria are that all compound fractures, fractures of ipsilateral ulna were excluded. The cases were grouped as per Melon's classification of intra articular fractures distal radius.

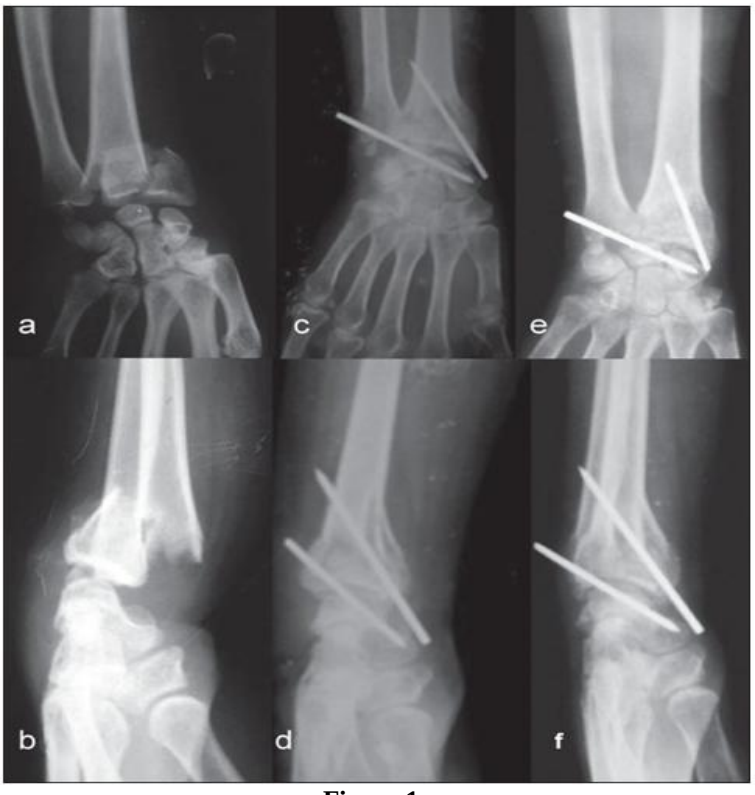


Figure 1:

Pre-operative anteroposterior and lateral (a, b) xray of the left wrist shows comminuted intraarticular fracture distal end radius (Melon's type-II) with fracture ulnar styloid. Immediate post operative and anterioposterior and lateral X-rays (c, d) and 6 weeks follow-up anteroposterior and lateral X-rays (e, f) shows evidence of union, maintenance of alignment of DRUJ, radial length, normal radial tilt.

The patients were treated by closed reduction and percutaneous stabilization of ulnocarpal articulation under an image intensifier. The fracture was immobilized in a well moulded above elbow plaster of paris (POP) cast for 6 weeks .The patients were followed at 3 weeks interval upto 6 weeks and then at 6 weeks interval for 1 year.(Figure.1)

Results were evaluated clinically and Radiologically at 1 year follow up(Figure.2) using the Sarmiento's modification of Lindstrom's criteria(Table -1) and the functional evaluation by the Demerit point system of Gartland and Werley's with Sarmiento et al 's modification.(Table - 2)

Table 2 : Demerit point system of Gartland and Werley's with Sarmiento et al modification (functional evaluation)

Result	Points
Residual deformity	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2 – 3
Point range	0 – 3
Subjective evaluation	
Excellent –no pain, disability, or limitation of motion	0
Good – occasional pain, slight limitation of motion, no disability	2
Fair – occasional pain ,some limitation of motion ,feeling of weakness in wrist No particular disability ,activities slightly restricted	4
Poor – pain, limitation of motion, disability, activities more or less markedly restricted	6
Point range	0 – 6
Objective evaluation *	
Loss of dorsi flexion	5
Loss of ulnar deviation	3
Loss of supination	2
Loss of plamar flexion	1
Loss of radial deviation	1
Loss of circumduction	1
Loss of pronation	2
Pain in distal radioulnar joint	1
Grip strength – 60% or less of opposite side (using dynamometer)	1
Point range	0 - 5
Complications	
Arthritic changes	
Minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications (Median)	1 – 3
Poor finger function due to cast	1 – 2
Point range	0 – 5
End result point ranges	
Excellent	0 – 2
Good	3 – 8
Fair	9– 20
Poor	21 and above

*The objective evaluation is based on the following ranges of motion as being the minimum for normal function-dorsiflexion-45º, palmar flexion-30º, radial deviation-15º, ulnar deviation-15º,pronation-50º, supination- 50º.

Melon's classification of intraarticular fractures (subtype of universal classification)

- Type 1 – undisplaced
- Type 2 – medium column displacement (die punch fracture)
- Type 3- segmental radial shaft (butterfly fragment) component
- Type 4 – transverse split of articular surfaces with rotational displacement

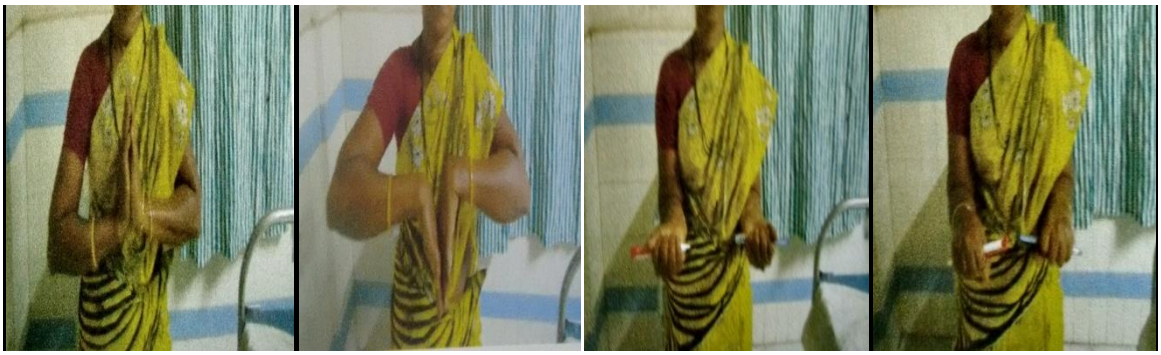
Measurement of various angles

The various angles measured were as described :

Palmar tilt (RT): This is measured in true lateral x-ray of the wrist .A line perpendicular to the central axis of the radius is drawn through the dorsal rim of the distal radius. Another line joins the dorsal and ventral rim of the radius. The angle of palmar tilt is 0-22º.

Radial Length (RL): In true anteroposterior x-ray of the wrist, two lines are drawn perpendicular to the long axis of radius, one joining the tip of radius styloid and the other joining the distal articular surface of the ulna. The distance between these two lines is called radial length and should be 11-12mm.

Radial angulation (RA) : In true AP x-ray of the wrist ,a line perpendicular to the central axis of the radius is drawn .Another line joins the distal tip of the radial styloid and the ulnar corner of the ulnar fossa. The angle between lines 1 and 3 normally measures 16 - 28º (in true skiagram of wrist)



A B C D

Figure 2: follow up clinical photograph of the same patient shows dorsiflexion and palmarflexion (A,B) supination and pronation (C,D) radialand ulnardeviation (E,F)

E F

Operative procedure

Closed reduction is done by longitudinal traction ,and direct pressure on displaced radial fragment depending upon the displacements of fragments under general or regional anesthesia and the reduction was checked by an image intensifier .The goal is to approximate the palmar cortex. While maintaining the position and keeping forearm in 30º supination, the first k –wire (2- 2.5mm) is passed through the dorsomedial border of distal ulna about 1.5 cm proximal to ulnar styloid at 45º from long axis of ulna in distal and radial direction and 10 - 15º ventral direction into the adjacent carpal/carpals (lunate /scaphoid).Another k –wire is passed from the ventro-lateral aspect of radial styloid at 45º with the long axis of radius 10 - 15º dorsally and medially so as to penetrate the medial cortex of proximal segment of radius, under the control of image intensifier ,and the position was checked in AP and lateral views. A well moulded above elbow POP cast is given. Postoperatively the limb is kept elevated, and active shoulder and finger movements are started at the earliest. The POP and k –wires are removed after 6 weeks and physiotherapy of wrist and forearm started.

III. Results

A total of 100patients with communitted colles fracture with an average age 52 years (20-70years) were included in this study. Of those 56%are on left side and 44%right side. Fall on outstretched hand (n=80) was the most common mode of injury ,followed by high energy trauma(RTA).Assosciated injuries(9%), of them supracondylar fracture humerus (ipsilateral-2%), intracapsular fracture neck of femur

(ipsilateral-4%),bilateral colles(3%).Results were assessed clinically and radiologically according to anatomical and functional criteria and were compared with the normal wrist. For the bilateral cases where the normal wrist was not available for comparison, the results were evaluated in relation to the documented normal values.

Anatomically 64% fractures had excellent restoration of anatomy, 28% fractures had good restoration of anatomy,4% had fair and 4% had poor restoration .Thus 92% fractures had excellent to good alignment fragments

Table 3: Functional evaluation – Demerit point system of Gartland and Werley's

	Score	No.of cases (%)
Excellent	0 – 2	48
Good	3 - 8	44
Fair	9 - 20	4
Poor	21 and above	4

Functionally 48% had excellent and 44 % had good restoration of function, 4% fair ,4% poor function because of either poor reduction or lack of cooperation in exercise programme.(Table -3)

Thus overall 92% fractures had excellent to good results, 4% fair and 4% poor results.

The complications encountered were residual pain (n=4),joint stiffness (n=8),deformity (n=4),reduced grip strength (n=8), restriction of finger movements, pin tract infection (n=9),pull out of k – wires (n=5), sudecks osteodystrophy (n=5).

IV. Discussion

The ideal treatment of fracture of lower end of radius is yet to emerge. Treatment modality should satisfy both functional and cosmetic results. Closed reduction and POP cast is still practiced in developing countries because of limited facilities. Its merits include no need for metal insertion, cost effectiveness and less time consuming. High incidence of failure in grossly comminuted fractures and loss of reduction after successful reduction are the most common demerits. Conventional immobilization with POP cast often does not prevent early collapse and high risk of malunion, joint stiffness, DRUJ instability and painful wrist and is good only for (a) stable extra articular fractures and (b) low demand elderly patients[7,33].

Various techniques like Pin and plaster, percutaneous pinning of distal fragment ,external fixation, open reduction and internal fixation, and a combination of above have been described to prevent collapse/loss of reduction ,with their own advantages and disadvantages.

The disadvantage of incorporating pins into the circumferential plaster has led to a reevaluation of pin and plaster technique[34] .Chapman[35] in a study reported no shortening in 44%,1-5mm of radial shortening in 30%,and more than 5mm of radial shortening in 26%.Other complications reported were significant pin tract infection (20%), osteomyelitis (9%),iatrogenic fractures(9%), neurosensory complications (13.7%),and pin loosening (21%).

Percutaneous pinning of radial styloid fragment to opposite cortex by Munson and Gainor[36] reported restoration and conservation of radial angle in 87% and radial length in 92% of fractures but suggested that the technique is not good for elderly with thin cortices of osteoporotic bones. Percutaneous pinning of radius is biomechanically unstable and the oblique orientation of pins is unable to prevent radial collapse. Hochwald and associates[37] reported 9 % extensor tendon injury, 32% superficial radial nerve injury, along with pin tract infection and migration of pins as important complications of this technique.

Nonnenmacher and Kempfe[38] described 90% satisfactory results using Kapandji's intrafocal pinning .David [39]emphasized upon the tendency of distal fragment to displace in opposite direction, preventing the palmar cortex from reducing anatomically. The technique gives poor results with extensive communition, osteoporosis, or intraarticular fractures. Thus various methods of percutaneous pin fixation described till date have loss of reduction as one of the most common complications .External fixators can maintain the radial length and angle by ligamentotaxis but cannot effectively maintain the palmar tilt of the distal articualr surface [40].The thick ,strong V shaped volar ligaments have been shown to reach maximum tension when compared with the Z – shaped dorsal ligaments. With longitudinal traction ,this anatomic configuration predisposes the fracture to maintain dorsal tilt. With the use of external fixators complications have been reported to be as high as 60% and include added risk of loosening of pins, pin tract infection[41], Sudeck's osteodystrophy,radial sensory neuritis, and iatrogenic fracture through the pin site. The detrimental effects of over distraction include finger clawing, inability to make fist ,delayed union and residual stiffness. Several detailed studies[40, 42] have documented that external fixators alone may not be sufficiently rigid to prevent some degree of collapse and loss of palmar tilt during healing.

Open reduction and internal fixation is not frequently used because of technical problems in stabilizing multiple small cancellous fragments in an osteoporotic bone and has complications such as loss of fixation and

complications of open surgery. This method has limited indications, such as partial articular fractures, complex intraarticular fractures, and failed closed reduction[25].

Combined ORIF and external fixators have lead to extensive soft tissue stripping[43] .Ruch[44] compared the outcome of arthroscopy assisted reduction, percutaneous pinning and external fixation with fluoroscopy assisted reduction, and percutaneous pinning and external fixation and concluded that although arthroscopy provides superior visualization of articular surface and ulnar sided components of injury achieved a greater degree of supination, flexion and extension. The fluoroscopic assisted reduction, external fixation permits some collapse during healing, which may retract from subsequent radiographic outcome. Radial shortening, knirk and Jupiter congruity grades and DASH scores were similar for both groups.

Taking into consideration mainly, the cortical nature of distal intact ulna and intact carpals in these fractures ,we stabilize the ulnocarpal joint ,which indirectly helps to align the fracture fragments(ligamentotaxis) to maintain the radial length, the articulating surfaces of the distal radius, realigning the TFCC and DRUJ and also preventing the collapse during fracture healing. A biomechanical study by Graham et al[29] on percutaneous pinning of distal radius fractures concluded that constructs in which ulna is engaged provide superior resistance to fracture displacement. Our aim in this study is to maintain the reduction achieved, to retain the preinjury anatomy to as near as possible. Ulnocarpal fixation after closed reduction and restoration of anatomy helped in realigning the TFCC (a hole of 2- 2.5mm smooth k-wire is of no consequence).DRUJ dysfunction (pain and limitation of forearm rotation) is a main cause of residual wrist disability[45].DRUJ instability (subluxation), intraarticular incongruity, and ulnocarpal abutment are the main factors for DRUJ dysfunction despite perfect anatomical reduction of distal radius. Thus good alignment of ulnocarpal joint during reduction and healing is an important consideration to bring about good anatomical and functional outcome.

.The percutaneous fixation by this technique is an effective method to maintain the reduction and prevent collapse of radius fragments as well as to maintain the stability of DRUJ, even when the fracture is grossly communited, intra articular, or is unstable. The procedure is of short duration and can be done under general, regional, or even local anaesthesia. Also the removal of k-wires can be done as an outpatient procedure A study reported by Rayhack[21] compared radial styloid pinning, radial styloid and posteromedial pinning, and transulnar pinning and concluded that two pin Clancey method was least stable, followed by radial styloid pinning. The most stable technique was that of transulnar pinning.

The present technique transfixes the two cortical bones i.e., ulna and carpals and stabilizes the ulnocarpal bones ,making it still more stable, hence the incidence of radial shortening of more than 6mm was seen only in 4%of our fractures when compared with 26%as reported by Chapman[35].Four out of 27 patients reported by Rayhack et al had pin breakage while rupture of extensor tendons /tendinitis (2%) and redisplacement of fracture fragments (14%) as reported by Nonnenmacher and Kempfe[38] were not seen in any of the cases of this series.

V. Conclusion

The percutaneous pinning by this method is least invasive, yet an effective method to maintain the reduction and stability of distal radioulnar joint and prevent collapse of radial fragments during healing ,even when the fracture is grossly communited, unstable or intraarticular. Overall excellent to good results (92%) in our study suggest that stabilizing lower end ulna with carpals, stabilizes the TFCC, which is the main stabilizer of DRUJ and maintains the radial length, which is a crucial factor in regaining the functions of the wrist joint.

References

[1]. Alffram PA, Bauer GC.Epidemiology of fractures of the forearm; A biomechanical investigation of bone strength .J Bone Joint Surg Am 1962;44:105-14.
[2]. Bacron RW ,Kurtzke JF. Colle's fracture :A study of two thousand cases from the New York states compensation board. J Bone joint Surg Am 1953;35;643-58
[3]. Fernandez DL ,Jupiter JB, editors. Fractures of the distal radius;A practical approach to management. NewYork.NY;Springer – Verlag ;1996
[4]. Fernandez DL .Correction of posttraumatic wrist deformity in adults by osteotomy, bone grafting and internal fixation. J Bone Joint Surg Am 1982;64:1164-78.
[5]. Fernandez DL .Radial osteotomy and Bowers arthroplasty for malunite fractures of the disatal end of radius.J Bone Joint Surg Am 1988;70:1538-51
[6]. Green DT .Pins and plaster treatment of comminuted fractures of the distal end of radius .J Bone Joint Surg Am 1975;57:304-10.
[7]. Jupiter JB ,Ring D,Weitzel PP ,Surgical treatment of redisplaced fracturw of the distal radius in patients older than 60 years. J Bone Joint Surg Am 2002;27:714-23.
[8]. Zemel NP .The prevention and treatment of complications from fractures of the distal end of radius and ulna. Hand clinic 1987;3:1-11.
[9]. Weber ER .A rational approach for the recognition and treatment of Colle's fracture .Hand Clinic 1987;3:3-21.
[10]. Peltier LF .Fractures of the distal end of radius; An historical account .Clin Orthop Rela Res 1984;187:18-22.
[11]. Hastings H 2nd, Leibovic SJ .Indications and technique of open reduction :Internal fixation of distal radius fractures. Orthop Clin North Am 1993; 24:309-26

[12]. Ark J , Jupiter JB .The rationale for precise management of distal radius fractures. Orthop Clin North Am 193;24:205-10.
[13]. Slagel BE ,Leunam S ,Pichora DR .Management of post traumatic malunion of fractures of distal radius .Orthop Clin North Am 2007;38:203-16.
[14]. Arora J,Kapoor H ,Malik A. Bansal M ,Closed reduction and plaster cast immobilization Vs external fixation in comminuted intraarticular fractures of distal radius .Indian J Orthop 2004 ;38:113-7.
[15]. Castaing J.Recent fractures of the inferior extremity of the radius in the adult.Rev Chir Orthop French 1964;50:582-696.
[16]. Mah ET ,Atkinson RN .Percutaneous Kischner wire stabilization following closed reduction of Colle's fracture .J Hand Surg Br 1992;17:55-62.
[17]. DePalma A.Communited fractures of the distal end of radius treated by ulnar pinning.J Bone Joint Surg Am 1952;34:651-62
[18]. Stein A .Katz S.Stabilisation of communited fractures of distal inch of the radius : percutaneous pinning .Clin Orthop Rela Res 1975;108:174-81
[19]. Rayhack J M,.The history and evolution of percutaneous pinning of displaced distal radial fractures..Orthop Clin North Am 1993;24:287-300.
[20]. Kapandji A.Internal fixation by double intra focal pinning: Functional treatment of non articular fractures of the distal radius [French].Ann Chir Main 1987;6:57
[21]. Rayhack J ,Langworthy J,Belsole R.Transulnar percutaneous pinning of displaced distal radius fractures : A preliminary report. J Orthop T rauma 1989;3:107.
[22]. Edwards Gs Jr.Intra – articular fractures of the distal part of the radius treated with the small AO external fixators. J Bone Jooint Surg Am 1991;73:1241-50.
[23]. Huch K ,hunerbein M,Meeder PJ .External fixation of intra articular fractures of the distal radius in young and old adults .Arch Orthop Trauma Surg 1996;115:38- 42.
[24]. Ruch DS ,Ginn TA .Open reduction and internal fixation of distal radius fractures .Op Tech Orthop 2000;13:138-43.
[25]. Schnur DP,Chang B.Extensor tendon rupture after internal fixation of a distal radius fracture using a dorsally placed AO/ASIF titanium piplate :Ann Plast Surg 2000;44:564-6.
[26]. Bass RL .Blair WF ,Hubbard Pp.Results of combined internal and external fixation for the treatment of severe AO-C3 fractures of the distal radius .J Hand Surg Am 1995;20:373-81.
[27]. Rikli DA ,Kupfer K,Bodoky A.Longterm results of the external fixation of distal radius fractures .J trauma 1998;44:970 -6.
[28]. Doi K,Hattori Y. Otsuka K,Abe Y.Yamamoto H. Intra articular fractures of the distal aspect of the radius: Arthroscopically assisted reduction compared with open reduction and internal fixation .J Bone Joint Surg Am 1999;81:1093- 110.
[29]. Graham T.Martins H ,Louis D ,et al .Biomechanical evaluation of percutaneous pinning for extra articular fractures of distal end radius .Presented at the American Society for surgery of hand residents and felloes conference .Toronto, Canada :September 23,1990.
[30]. Melon CP Jr. Aricular fractures of distal radius .Orthop Clinic North Am 1984;15:217.
[31]. Sarmiento A, Pratt GW, Berry NC, Sinclair WF .Colle's fractures ,functional bracing in supination. J Bone Joint Surgery Am 1975;57:311-7.
[32]. Gartland JJ Jr,Werley CW. Evaluation of healed colles fractures. J Bone Joint Surg Am 1951;33:895- 907.
[33]. Ark J, Jupiter JB .The rationale for precise management of distal radius fractures.Orthop Clinic North Am 1993;24:205-10.
[34]. Jupiter JB .fractures of the distal end of radius .J Bone Joint Surg Am 1991;73:461- 9.
[35]. Chapman DR ,Bennett JB ,Bryan WJ, tullos HS. Complications of distal radial fractures :Pins and plaster treatment .J Hand Surg Am 1982;7:509-12.
[36]. Munson GO, Ginor BJ .percutaneous pinning of distal radius fractures .J trauma 1981;21:1032-5.
[37]. Hochwald NL ,Levine R, Tornetta P 3rd .the risk of kirschner wire placement in the distal radius :A comparison of technique .J Hand Surg Am 1997;22:580-4.
[38]. Nonnenmacher J ,Kempfe I,Role of intra focal pinning in the treatment of wrist fractures.In t Orthop 1988;12:155-62.
[39]. Ruch DS ,Rockwood and Grens fractures in adults ,6th e. Published by Lippincott Williams and Wilkins;2006.p.925.
[40]. Chan BK ,Leong LC <Low CO, See HF.The use of external fixators in treatment of intra articular fractures of the distal radius Singapore Med J1999;40:420-4
[41]. Gausepohl T, Penning D, Mader K,principles of external fixation and supplementary technique in disatal radius fractures. Injury 2000 ;31:56-70.
[42]. Sanders RA,Keppel FL Waldrop JI. external fixation of distal radius fractures :Results and complications J Hand Surg Am 1991;16:385_91.
[43]. Ruch DS,Yang C,Smith BP. :Results of palmar plating of the lunate facet combined with external fixation for the treatment of high energy compression fractures of the distal radius .J Orthop Trauma 2004;18:28-33
[44]. Ruch DS, Vallee J, Poehling GG, Smith BP, Kuzma GR .Arthroscopic reduction versus fluoroscopic reduction in the management of intra articular distal radius fractures. Arthroscopy 2004;20:225-30 .
[45]. Geissler WB,freeland AE. Arthroscopically assisted reduction of intra articular distal radial fractures. Clin Orthop Related Res 1996;327:125-34.c.