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OPEN REDUCTION AND INTERNAL FIXATION WITH CORTICOCANCELLOUS BONE GRAFT FOR TREATMENT OF VOLARY MALUNITED FRACTURE OF DISTAL RADIUS

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Abstract

Malunion of the distal radius is actually a late complication, not salvageable by re-manipulation or a change of immobilization, it requires different management technique. The aim of this study is to choose a technique that corrects the deformity as much as possible, with less complications.

An assessment was done for 24 patients with unilateral malunited fractures of the distal radius. The mean age was 42 years (range 25-61 years). They were treated by open-wedge volar osteotomy with corticocancellous graft from upper tibia. Both osteotomy and graft were fixed by volarly applied plate and screws. Preoperative antero-posterior and lateral wrist radiographs were obtained and fracture pattern and radio-carpal alignment were assessed. Radial length and palmar tilt were also measured. The clinical outcome was assessed depending on the modified Gartland and Werley score. Radiological assessment of the parameters was done postoperatively to detect how much these parameters were corrected.

This study shows that volar open-wedge osteotomy with corticoocancellous bone graft and internal fixation is a method for correction of malunited distal radial fractures with encouraging results. About 90% of the patients were satisfied with their results regarding the correction of the deformity and improvement of wrist and hand function, as well as limited complications when it is done carefully with appropriate facilities.

In conclusion, the corrective osteotomy should be considered only when there is a clear-cut indication. It is actually a method to correct the deformity, rather than treatment of symptoms, specially pain.

Introduction

The distal radial fractures represents one of the greatest challenges to the surgeon treating wrist injuries. Unless certain treatment criteria are met, these fractures will not do well and the result will be a painfully stiff and dysfunctional wrist[1,2]. The goals of treatment are to restore maximum function, maintain strength, limit the development of post-traumatic osteoarthritis, and avoid complications. The goals of treatment specify that the physician achieve and maintain a satisfactory reduction until healing occurs and then rehabilitate the wrist to restore motion and strength. Four measurements obtained from the plain films are useful for pretreatment assessment of the position of the distal radius as a whole: radial inclination (normal=23-24°), volar (palmar) tilt (normal=9-11°), radial height (normal=9-12 mm), and radial shift (or width) as shown in figure 1. Radiographs of both wrists are compared and the measurements should differ by no more than 1 mm[3].

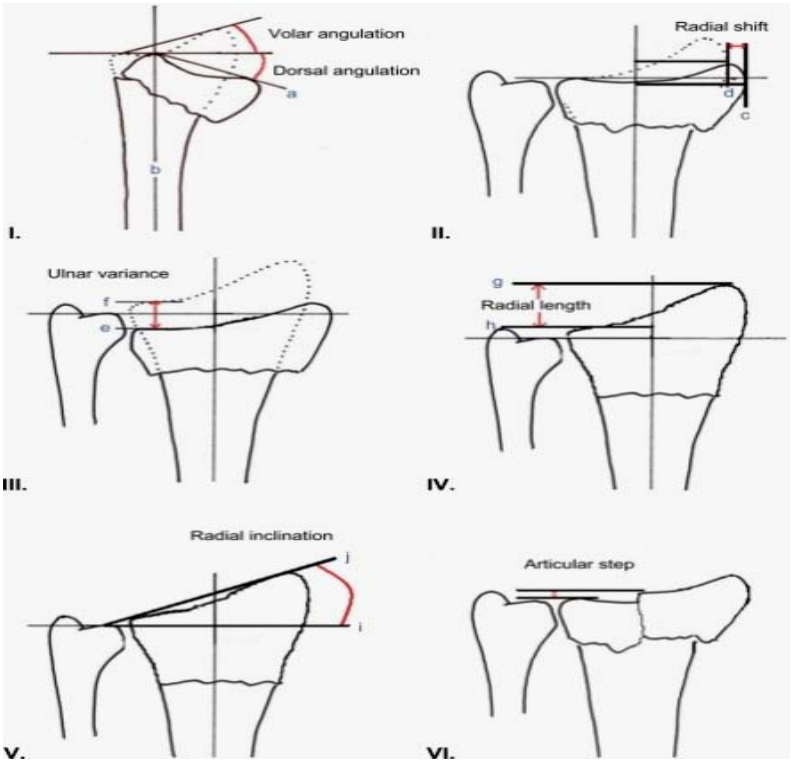

Figure 1: Assessment of the position of distal radius

Severe dorsal or volar angulation and/or severe comminution at presentation, and incomplete reduction are signs of likely redisplacement and subsequent deformity after cast treatment. Intra-articular fractures deserve special attention, several studies have shown a correlation between final incongruency and the development of degenerative changes and a worse clinical outcome[1,3,4]. Although there was a higher incidence of degenerative changes in the intra-articular fractures compared with the extra-articular fractures, there was no difference in clinical outcome between them[3].

Malunion remains one of the most commonly observed complications of a fracture of the distal part of the radius[5,6]. Malunion is a late complication, not salvageable by re-manipulation or a change of immobilization; it is usually require different management technique as opening wedge osteotomy, insertion of a corticocancellous graft, and a buttress plate[3].

There are two types of malunion: Nascent malunion: patient presents with poor radiographic alignment before complete healing of the fracture and before a sufficient period of exercise (before or shortly after cast removal). Mature malunion: patient presents with functional problem that may be related to inadequate alignment of a healed fracture. Corrective osteotomy for nascent malunion can be done easily through the fracture line[7]. The original fracture line can be identified and recreated up to 2-3 months and if delayed, osteotomy at an appropriate level may be necessary. Earlier correction also may help to prevent maladaptive soft tissue contractures and arthrosis of the distal radioulnar joint[8].

Patients and Methods

A prospective study in which twenty four skeletally mature patients were evaluated at an average follow-up period of twelve months (range between 6 and 18 months) after corrective volar open-wedge osteotomy for volary mal-united distal radial fractures. The study group included twenty one males and three females.

The mean age 42 year (range, twenty five to sixty one year) (Table I). Fifteen fractures occurred in the right wrist, and nine occurred in the left wrist. Fourteen wrists were with extra-articular mal-union, four wrists were with intra-articular mal-union, and six patients had combined intra-articular and extra-articular mal-union. All fractures were the results of apparently high-energy trauma (sixteen fall and eight motor-vehicle accident).

All fractures, except one, were treated conservatively by cast with or without manipulation. One patient was treated by percutaneous wires fixation. The patients are presented because of deformity, weak grip, and limitation of forearm rotation. The pain was not a chief complaint. The time interval from the injury to the osteotomy was range from one to six months (Table II).

Table I: The age distribution

Age group	No.	%
25 - 45 year	17	71
45 - 65 year	7	29

Table II: Time interval from injury to surgery

Time interval	No.	%
1 - 3 months	14	58
3 - 6 months	10	42

Preoperative clinical and radiological evaluation was done. Clinically, all patients were with obvious wrist deformity (volarly displaced wrist). On radiograph, there is a volar tilt >12° as measured on lateral view, and radial shortening >2 mm as measured on anteroposterior view. Radiograph of the opposite wrist was also done for comparism. The cases with intra-articular mal-union, there is articular step-off or gap about 2-4 mm, and/or volar subluxation of the radiocarpal joint.

The indications for the osteotomy include: severe extra-articular mal-union (volar tilt >12°, normal within10°) as measured on lateral radiograph, volar subluxation of the radiocarpal joint, and articular incongruity ≥2mm as measured on anteroposterior radiograph. These criteria are nearly the same criteria which were considered by Ring et al[9] in their study.

Surgical technique: general anesthesia usually used. The operative approach was volar approach. The volar exposure is usually adequate through the distal 6-8 cm of the Henry approach[10]. The incipient callus is removed when possible, if the fracture line is seen the corrective osteotomy is usually done through the fracture line i.e. recreate the original fracture line, and when it is necessary to visualize the articular surface, it is usually through the fracture site without incision of the volar wrist capsule. Reduction is monitored under image intensification with realignment of the metaphyseal fracture lines. When the fracture line is not obvious the osteotomy is done about 4mm below the subchondral bone. The osteotomy was done by electrical saw and the size of the open-wedge is detected according to preoperative x-ray template and the normal side is used as a guide for amount of correction. The correction is confirmed by image intensifier. The osteotomy site is fixed by preliminary K.wires and then replaced by mini T-plate and screws. The osteotomy gap is filled by corticocancellous graft harvested from upper tibia. The T-plate will hold both the osteotomy and the graft.

Postoperative evaluation: at the final, follow-up was done: functional, clinical, and radiological assessment. The patients were asked about satisfaction and

function. The pain score was measured on a visual analogue scale in which zero indicated no pain and ten is the worst conceivable pain[11] (Figure 2).

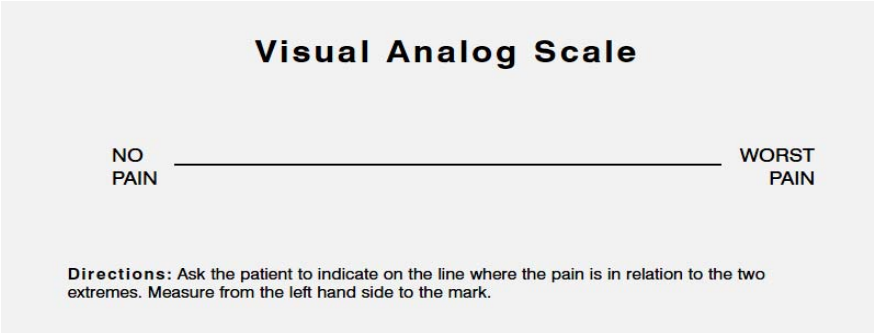

Figure 2: Visual analog scale

Movement at the wrist and forearm was measured with a goniometer (Table III). The grip strength was recorded using sphygmomanometer cuff due to unavailability of the standard grip dynamometer (Table IV). Contralateral normal side was used as a guide for scoring. The results were graded depending on the system of modified Gartland and Werly[12].

Table III: Preoperative percentage of range of movement in comparison with contralateral side

% range	Wrist flexion	Wrist extension	Supination	Pronation
20 - 40	10(41%)	14(58%)	13(54%)	5(21%)
40 - 60	9(38%)	8(34%)	9(38%)	13(54%)
60 - 80	4(17%)	2(8%)	2(8%)	4(17%)
80 - 100	1(4%)	0(0%)	0(0%)	2(8%)

Table IV: Postoperative percentage of range of movement in comparison with contralateral side (after 6 months)

% range	Wrist flexion	Wrist extension	Supination	Pronation
20 - 40	0(0%)	1(4%)	2(8%)	0(0%)
40 - 60	1(4%)	3(12.5%)	1(4%)	0(0%)
60 - 80	16(67%)	16(67%)	16(67%)	5(21%)
80 - 100	7(29%)	4(16.5%)	5(21%)	19(79%)

Radiographs were taken before operation and at follow-up for assessment of radial height, volar tilt, and articular congruity compared with the contralateral wrist[13].
The articular incongruity was assessed as described by Knirk and Jupiter[1]: articular incongruity was graded as 0, 0 to 1 mm step-off; 1, 1 to 2 mm step-off; 2, 2 to 3 mm step-off; and 4, >3 mm step-off.

Results

Surgery was relatively smooth in almost all the patients. The wound was healed satisfactorily in all patients without deep infection or metal failure. No infection or other serious complications had been reported in the donor site of the bone graft (the upper tibia).
Above elbow back slab usually was applied for 3 weeks postoperatively, then it is replaced by a removable splint interrupted during the day by periods of active wrist and forearm exercises. The splint continues until fracture healing. The range of active wrist and forearm movements, and grip strength was gradually improved on serial follow-up

sessions (three weeks, six weeks, three months, and six months). Some patients needed physiotherapy course in a special physiotherapy center and more follow-up.

Outcome: a total of 22 of the 24 patients (91%) were satisfied with their results. Most patients had no pain and in some it was intermittent especially on activity (VAS about 1.5). At final, the mean active range of movement in the affected wrists was: supination about 80% of the opposite side, pronation about 90%, flexion 78%, extension about 75% of the contralateral side (Table V). The grip strength was about 80% of the contralateral side (Table VI). The results were statistically significant (p value > 0.05). All patients had full flexion and extension at the metacarpophalangeal and the inter-phalangeal joints.

Table V: Preoperative grip strength percentage in comparison with contralateral side

% grip strength	No. & %
20 - 40	4(17%)
40 - 60	18(75%)
60 - 80	2(%)
80 - 100	0(0%)

Table VI: Postoperative grip strength in comparison with contralateral side (after 6 months)

% grip strength	No. & %
20 - 40	0(0%)
40 - 60	2(8%)
60 - 80	14(58%)
80 - 100	8(34%)

Using subjective and some objective criteria of the modified Garland and Werley[12] score, excellent to good results were obtained in 70% of the patients. Actually, this study depends mainly on the subjective part (questionnaire) of the Garland and Werley, as Annechien Beumer et al did, they found that the subjective part of the Garland and werley assessment score may be as sensitive as the objective part of the score[14].

Superficial wound infection occurred in two patient and respond well to local wound care and short course of systemic antibiotics. One patient needed a subsequent surgery (Darrach operation) because of distal radioulnar joint arthrosis. Three patients needed early removal of metal (4-5 months), due to long screws irritating the extensor tendons. Two patients developed signs of reflex sympathetic dystrophy, both became relatively well after a period of supportive measures and physiotherapy.

Postoperative radiography: during the period of follow-up, all patients had complete healing of the osteotomy. Compared with contralateral radiographs, three patients had a volar tilt> 10° and all other patients had a normal volar tilt to within 10°. Twenty two patients had correction of the radial height within 2mm. From the ten wrists with intra-articular malunion, only in one there was a step between 1 mm and 2 mm (grade 1), while in the other nine wrists the intra-articular step ≤1 mm (grade 0). The patient with grade 1 intra-articular step remains complaining of intermittent pain especially on activity.

Discussion

Operative treatment of inadequately or imperfectly treated fractures of distal

radius can improve wrist and hand function substantially, but rarely restore the limb to normal. Most authors believe that there is a firm relationship between the quality of reduction and the restoration of function[15,16]. Malposition is related to the radial height, radial angle, volar tilt, and the accuracy of intra-articular fracture[1,17,18]. So restoration of these parameters is important to achieve a well-functioning wrist and hand.

The use of volar plate fixation has influenced the management of distal radial mal-union. The volar plate was applied in a buttress mode to support the osteotomy site and bone graft. Although, we were find that the volar open wedge osteotomy and grafting is technically demanding, but the results were encouraging regarding the restoration of the radial length and overall position of the wrist. Villar et al[19] showed that radiological shortening of the radius is most consistently correlated with poor function. But, sometimes there may be a pre-existing longer ulna before the injury, and not only posttraumatic radial shortening[14]. The only way to ascertains is to obtain radiographs of the contra-lateral wrist and assess ulnar length before surgery.

The results of corrective open-wedge osteotomy for the treatment of intra-articular mal-union are comparable with those for the extra-articular mal-union. This fact was seen in our study. It is also seen by Rodriguez and Carlos[3], they concluded that: although there was a higher incidence of degenerative changes in the intra-articular fracture group compared with the extra-articular fracture group, there was no difference in clinical outcome between the groups. Actually one or two year's follow-up is not enough to confirm this fact. Actually it needs longer period of follow-up. It is known that patients with intra-articular fractures with more than 2 mm incongruence have been found to get joint degeneration after 6.7 years[1]. The same goes for fractures with more than 10° of dorsal tilt[20,21] and carpal malalignment[22,23].

The causes of mal-union of distal end radius for the patients included in the study are probably related to:

1. Patients in whom, the medical care took the priority over the treatment of a musculoskeletal injury.
2. Fracture occurs in patients with relatively low physical demands in whom treatment was done relatively halfway despite the complexity of the injury.
3. Patients from areas far away from the professional healthcare centers.
4. Treating physician may be not fully aware about the correlation between the wrist and forearm function and the alignment of distal radius.
5. Unanticipated loss of reduction within the cast.
6. Patient and/or family afraid from surgery and its complications.

Corrective osteotomy is usually offered to patients who have sufficient mal-alignment that the surgeon thinks complications are inevitable or to patients in whom the functional deficit can be related obviously to the malunion[7]. In our study actually we were select the patients for osteotomy according to these conditions and we did the surgery only after explanation to the patients the cons and pros of the procedure and take their consensus.

In the study we were finding that the corrective osteotomy, especially the intra-articular one was easier during the nascent stage of mal-union when the original fracture lines often can be recreated with little additional damage has occurred. In mature stage of mal-union, the osteotomy was done about 4 mm distal to subchondral bone. The osteotomy site is selected by balancing the facility of deformity correction when the osteotomy is made at the site of the original fracture

with the desire to have a larger distal fragment to facilitate secure internal fixation[24]. Stable internal fixation and corticocancellous bone graft are used to stabilize the osteotomy and encourage healing.

The results of open wedge volar osteotomy and corticocancellous graft was encouraging regarding the correction of the wrist deformity, improvement of the hand grip strength and movements (wrist extension & forearm rotation) as compared with opposite normal side. This fact was confirmed in our study. Sato K et al[25] also noted that opening wedge osteotomy for volarly mal-united distal radius fracture restored bony configuration of the distal radius, decreased pain, and improved grip strength and range of wrist motion, particularly for forearm supination. Also it has been recognized that there is a correlation between the functional outcome following a distal radial fracture and the restoration of both the radiocarpal and radioulnar relationships[1].

There are some complications written in literature associated with volar plate fixation[26]. Irritations of the flexor carpi radialis and flexor pollicis longus tendon by plate itself as well as dorsal tendon irritation from screw prominence have been reported. Frank rupture of the extensor pollicis longus was also reported[27]. With volar plate fixation, there has been increased attention on the possibility of ischemic contracture of the pronator quadratus as a potential complication leading to limited forearm rotation after distal radial fracture, or specifically after fixation with a volar plate and tight repair of the pronator quadratus. It is usually presents as pain with passive supination and pronation. In theory ischemic injury could lead to contracture and limited supination[26]. Fortunately in this study, serious complications are not recorded apart from extensor tendon irritation by long screws which was treated satisfactorily by metal removal without change in the fracture alignment.

Conclusion

It is not our aim to encourage surgeons to operate on all patients with volary mal-united fracture of the distal part of the radius, especially those associated with slight displacement or little articular incongruity as there is significant risks of osteotomy that are reported in the literature[9] as technical difficulties, and the risk of additional injury, osteonecrosis of the subchondral bone, and nonunion of the osteotomy.

The indications of surgery are not always based on the symptoms alone, because by the time the symptoms especially pain develop, there may already be irreversible articular damage and the corrective osteotomy will be of no benefit and the wrist better to be salvaged by wrist arthrodesis, rather than the corrective osteotomy. The major indications for osteotomy are:

- Functionally symptomatic extra-articular mal-union as weak grip, limitation of wrist extension, and forearm supination.
- Significant articular incongruity and volar subluxation of the radiocarpal joint as shown on lateral radiograph.
- Articular step-off or gap>2mm as measured on posteroanterior view.

Osteotomy will be easier to create, manipulate, and heal if the fracture deformity is relatively not complex, the time after injury is short, and bone is of good quality. Small, osteoporotic, well-healed fragments and complex deformity is difficult to treat and may end with suboptimal results.

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