Management of non-united fractures radius/ulna with segmental defect in adults

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Abstract

Introduction

Nonunions of the ulna and radius shaft causes a severe functional impairment. Various treatment modalities were described in treating forearm bone loss. Nicoll's principle is the basis for the management of such injuries. This reading was done to evaluate results of using iliac graft augmented with rigid compression plate fixation for management of diaphyseal non union of radius/ulna with segmental defect.

Patients and Methods

A retrospective study included 12 patients with 18 nonunion treated between July 2013 and March 2017 for diaphyseal nonunion of radius or ulna or both. Including 8 men and 4 women, the age was 34 years (range: 25-50 years). The nonunion sites were twelve fractures in middle third, four fractures in proximal third and two in distal third. The interval between the injury and index procedure for the management of nonunion averaged 16 months (range: 6-28 months). All cases were managed by tapered tricorticocancellous iliac graft augmented with rigid compression plate fixation.

Results

The patients were observed for a mean of 26 months (range, 12-46 months). The mean period of the nonunion was 14.7 months. Eighteen bones showed union at both graft junctions. Mean elbow motion range was 121 degrees. The elbow extension was -5 degrees. The wrist flexion was 65 degrees and the mean wrist extension was also 65 degrees. The mean range of pronation was 72 degrees. According to Anderson score, 6 patients had excellent scores, three good and three fair.

Conclusion

Surgical management of non-union with decortication, tapered bone autograft and stabilization with bridging plate has achieved satisfactory results in our series.

Introduction

The surgical management of diaphyseal forearm fracture-nonunions with a segmental bone defect remains a therapeutic challenge for orthopedic trauma surgeons. Nonunion is often due to high-energy trauma with a huge loss of tissue, gunshot wounds, following excsion of primary and metastatic bone tumors, healed osteomyelitis with segmental nonunion, or a complication of compound fractures with failed primary fixation. As a result, the most of nonunions are atrophic and result in bone defect. [1]

Nonunions of the radius/ulna shaft causes a severe functional and anatomic impairment, related to disruption of the interosseous membrane and dysfunction of the nearby joints, elbow and wrist. The management of these demanding nonunion and associated bone defects must include reestablishment of length and arrangement in order to restore functional forearm motion. [2]

Various treatment modalities described in treating forearm bone loss include using pausterized bones, use of cortical tibial graft fixed with screws, use of iliac graft to fill the bone defect and fixation with an intramedullary nail, cancellous insertion grafts with plate fixation, bone transport in radius/ulna using the principles of Ilizarov, using fibula as abone graft and with a tibial cortical graft fixed opposite to a plate, and vascularized fibular iliac bone graft. The salvage techniques such as centralization of one bone as a management of segmental bone defect in radius/ulna has been also described. [3-5]

Davey [6] modified Nicoll's technique and used blocks of the corticocancellous bone with a single cortex from iliac crest, augmented with rigid plate fixation under compression. Ring et al [1, 7, 8] used nonstructured autogeneous cancellous bone graft with

plate fixation in patients with a diaphyseal nonunion of radius and/or ulna and reported as a good result when the soft tissue coverage is compliant having limited scars, and consists of healthy muscles with a good blood supply. Edgardo [9] described good results using an Iliac crest bone graft with medullary fixation using a nail. [10]

Nicoll [11] removed the upper cortical plate of the iliac crest as "lid" and thin "wafer-like" cortical plates from the ilium and retained this cancellous insert in the defect with a platet without fixing the iliac graft. In this study, a part of the full iliac crest without removing any cortex (tricortical) was used and fixed with a compression plate.

This study was done to evaluate results of using tricorticocancellous iliac bone graft augmented with a rigid fixation by small compression plate fixation for management of diaphyseal non union of radius/ulna with segmental defect.

Patients and methods

This was a retrospective study of twelve patients (with 18 nonunion) treated between July 2013 & March 2017 for diaphyseal nonunion of radius/ ulna or both in orthoapedic department at Tanta and Kafr Elsheikh University Hospitals.

This study was approved by ethical committee of tanta university. An informed consent was signed by all patients after description of the surgical procedure.

The criteria for inclusion in present study were an adult more than 18 years with atrophic nonunion or oligotrophic nonunion with segmental bone defect measuring between 1 to 5 cm in length which were managed by tapered end tricorticcancellous iliac graft augmented with asmall compression plate and screws regardless prior surgical procedure, with some useful residual function of wrist and finger.

Cases with preoperative active infection, with neurological impairment of ipsilateral upper extremity or with poor residual function of hand or were excluded from this study.

Of these twelve patients, eight men (66.7%) and four women (33.3%), the average age was 34 years (range: 25-50 years)

There were 7 cases with fracture on the right side and 5 cases on the left side. Among them, eight patients had fracture on their dominant side.

According to site of lesions 6 cases had fracture of both bones forearm, four cases had isolated fracture ulna and two cases with an isolated fracture radius

The nonunion sites were twelve fractures in middle third, four fractures in proximal third and two in distal third.

The mode of injury was a motor vehicle accident for eight patients, a fall for two patients and work related injury for another two patients.

Six fractures were associated with open wound according to the system of Gustilo and Andreson[12], there were two type I, three type II and one type III fractures.

Two patients sustained an injury of ipsilateral upper extremity, including a fracture midshaft humerus and metacarpal fracture.

The intial management of the fractures consisted of plate and screws fixation in six patients, intramedullary rod fixation in four and cast immobilization in two patients.

Three patients developed deep infection, which were managed with debridement and parenteral antibiotics. All of the infections were quiescent at time of the index procedure for management of nonunion (followed by laboratory investigation CBC, ESR and CRP)

six patients had had at least one previous operative procedure and 4 patients had had 2 previous operative procedures (three of them for control of infection and one to achieve union)

The previous implants were thought to be of inadequate size in two patients (fixed by one third tubular plates) and one patient with inadequate length (fixed by two screws on both sides of fracture site). Including the six patients who initially had been managed with cast and intramedullary devices, nine patients (75%) were considered to have had suboptimal fracture fixation.

The interval between the injury and index procedure for the management of nonunion averaged 16 months (range: 6-28 months)

Table I: Patients demographic data

	Sex	Age	Bone	Open	Infect	Prev Op	Time be-fore op	Gap	FU	Union time	Side	MOT	Comp
1	F	38	R U	Closed	-	Plate	9m	20 40	46	14 16	R	Fall	
2	M	25	U	Closed	-	Plate	12m	50	30	14	R	MVA	
3	M	39	R U	OGIII	+	IM rod + Debr	11m	50 30	20	20 22	L	Work related	Stiff finger
4	F	45	R	Closed	-	Plate + BG	10m	30	24	18	L	MVA	
5	M	58	U	OGI	-	Cast	16m	15	22	20	R	MVA	
6	M	65	R U	OGII	+	IM rod + debr	24m	50 40	28	36	L	MVA	Heniation of muscle Infection Removal of plate
7	F	24	U	Closed	-	Plate	6m	20	12	14	L	MVA	
8	M	38	R U	OGI	-	Cast	13m	18 25	36	24 20	R	Work related	
9	F	41	R U	Closed	-	Plate	20m	40 25	28	14 16	L	MVA	
10	M	63	U	OGII	+	IM rod + debr	28m	50	30	50	L	Fall	Stiff finger+ graft for ulna
11	M	28	R	Closed	-	Plate	12m	15	20	16	R	MVA	
12	M	44	R U	OGII	-	Im rod + debr	16m	20 30	18	18	R	MVA	
Mean		42					14.7 m	30	26	18			

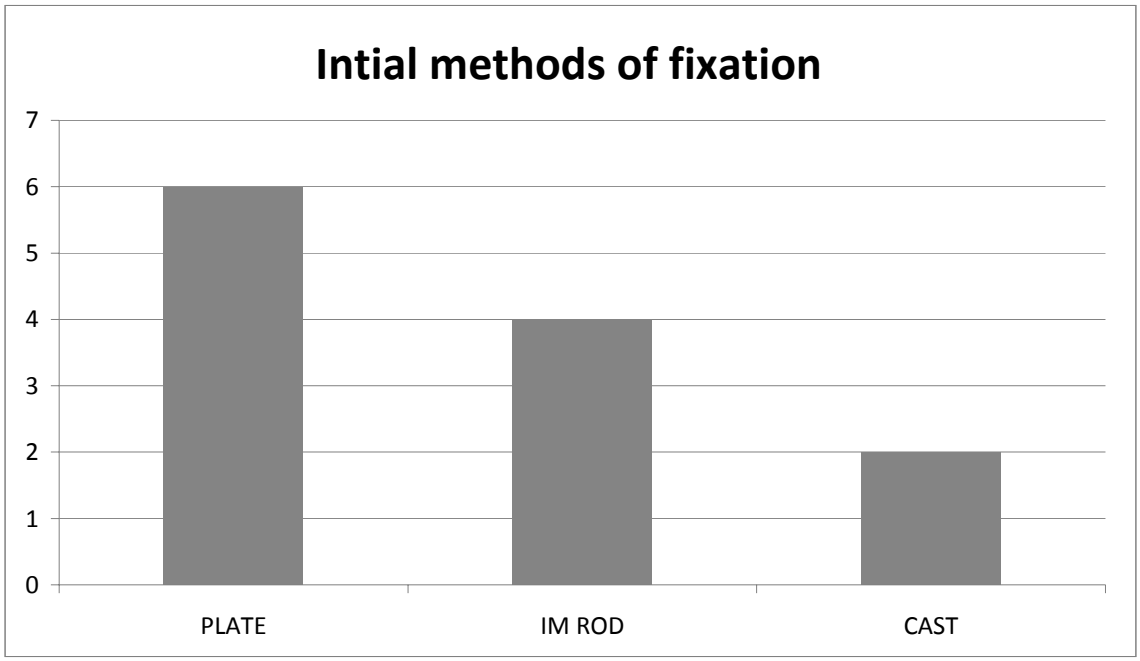

Figure 1: Initial methods of fixation

Operative technique:

The incision used was the traditional anterior approach of henry for the radius and the dorsal approach centerd on the ulnar edge for the ulna.

The first surgical step consisted of removing the loose implants, all surrounding scar tissues and scleroded bone fracture ends were removed till the fresh visible blood oozing surface was seen.

In all cases the medullary canal of each fragment at the site of the non union was opened by intramedullary drilling through the sclerotic bone. A gentle traction and counter traction was given to detect the gap between bony fragments.

At the donor site, a tricorticocancellous iliac crest graft was harvested. The graft length was one centimeter longer than the defect of the non union.

The cut ends of the bone block about 5 mm was trimmed on either sides and became centrally tapered on either sides to be inserted inside the medullary of both bony ends of the defect to increase area of bony contact and to allow graft to be compressed securely in place. (Fig 2,3)

Figure 2: tapered fashioned corticocancellous iliac graft

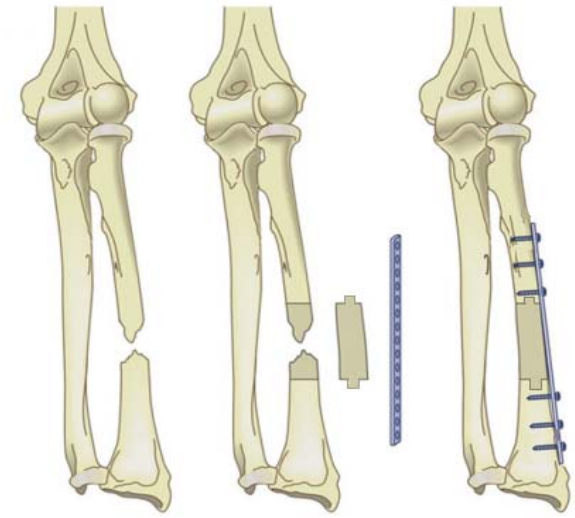

Figure 3: compression rigid plate fixing tricortical bone graft.

The defect was totally filled with bone and was augmented by 3.5 small compression plate which is longer sufficient to allow at least three bicortical screws on either sides of the non-union. In some cases the graft was fixed to the plate by screws. The cortical surface of the iliac graft was positioned opposite to the plate to allow secure compression without crushing. The appropriate length was determined using intraoperative image intensifier. Any remaining defects were filled with cancellous graft.

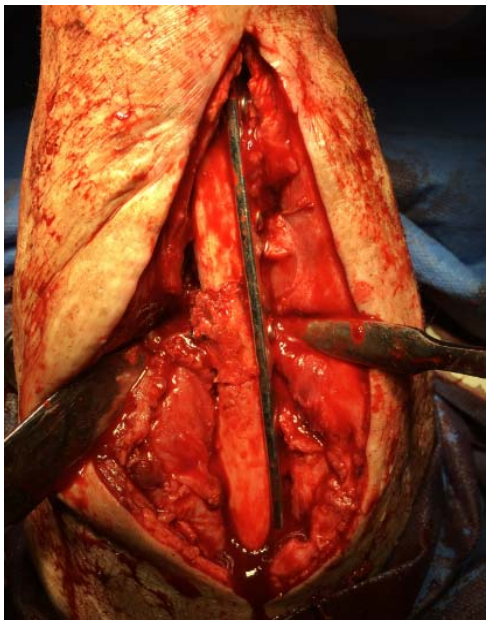

Figure 4: intraoperative photo showing graft compressed between 2 bony ends using compression plate.

The wound was closed in layers over suction drainage and the limb was immobilized in above elbow cast for the first three post-operative weeks. Patients were allowed to do passive & active exercise in cast. After removing the cast, they were encouraged to move the arm gently and not to lift heavy weights for 2-3

months till complete union. Patients were followed up monthly until radiological union occurred.

Patients were followed up using Anderson score (Table II) [13] and the post-operative pain was evaluated using the visual analogue scale (VAS) scored from 0-10 with zero indicating absence of pain and ten was maximum of pain.

Table II: Anderson score [13]

RESULT	UNION	WRIST ROM	SUPINATION PRONATION
Excellent	present	<10 ^{o} loss	<25 ^{o} loss
Good	present	<20 ^{o} loss	<50 ^{o} loss
Fair	present	<30 ^{o} loss	>50 ^{o} loss
Poor	non union with or without loss of motion		

Results

The patients were followed for a mean of 26 months (range, 12-46 months). The mean period of the non-union was 14.7 months.

Eighteen bones showed union at both graft junctions. The mean period of the union was 18 weeks (range, 14-50 weeks). One patient had delayed union, 2 patients had fingers stiffness and only one patient required regrafting of the ulnar side after 9 months of incomplete union.

One patient had infection but the fracture fully united. The infection disappeared after the removal of the plate by a standard procedure. One patient had muscles herniation at the surgical approach.

Mean elbow motion range was 121 degrees. The mean elbow extension was -5 degrees. The mean wrist flexion was 65 degrees and the mean wrist extension was also 65 degrees. The mean pronation range was 72 degrees. The mean supination range was 66 degrees. The motion range at elbow, wrist, supination/pronation, fingers and grip power improved significantly in all the patients from their preoperative level. None of the patients had neurovascular complications or implant breakage. (Figure 5)

According to Anderson score (Table III) [13], 6 patients had excellent scores, three good and three fair. According to VAS score [14], the mean score was 2. (Figure 6)

Table III: final score

	Bone	Flexion and extension elbow	Flexion and extension wrist	Pronation	Supination	Anderson	VAS
1	R U	140/0	80/70	80	80	Excellent	0
2	U	130/0	80/80	80	80	Excellent	1
3	R U	90/-20	30/30	70	40	Fair	5
4	R	140/0	70/80	80	80	Excellent	1
5	U	130/-10	80/70	70	60	Good	2
6	R U	90/-20	50/40	60	40	Fair	6
7	U	130/0	80/80	80	80	Excellent	1
8	R U	120/0	60/60	70	70	Good	2
9	R U	130/0	70/80	80	80	Excellent	0
10	U	100/-10	50/50	50	40	Fair	4
11	R	140/0	80/80	80	80	Excellent	0
12	R U	120/0	60/60	70	70	Good	2
Mean		121/-5	65/65	72	66		2

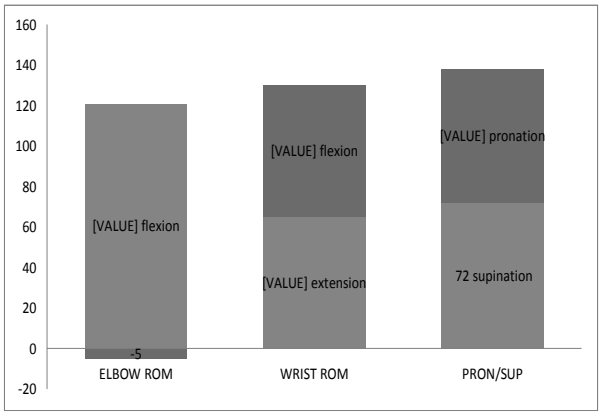

Figure 5: Mean ROM scores

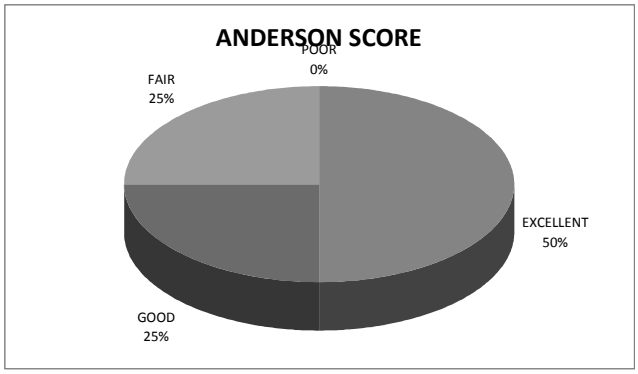

Figure 6: Final Anderson score

Figure 7: preoperative X ray showing non united fractures of ulna /radius fixed with IM rod.

Figure 8: preoperative X ray showing segmental defect of the radius & ulna after removal of IM

Figure 9: postoperative radiograph with fixation of iliac bone graft with a cortical 3.5 screw through dynamic compression plate.

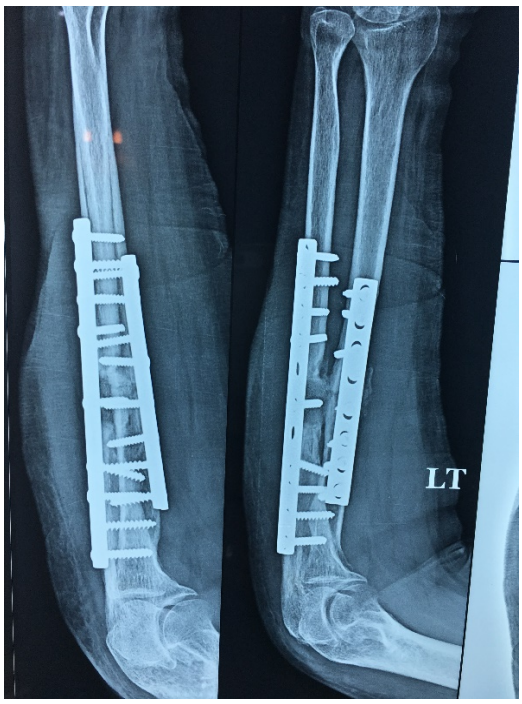

Figure 10: follow up X-ray showing complete union of both bones forearm

Discussion

Nonunion could be occured by factors such as comminuted or segmental fractures, bone defects, interposed soft tissue at the fracture site, damage of the blood supply in the fracture fragments, improper stabilization and local infection. [10]

Surgical management aims to regain proper length, retains the anatomy and recover forearm function. Nonvascularized autografts were the mostly used grafts and were considered to be the "gold standard." They have osteoinductive & osteoconductive properties also osteoprogenitor cells. A literature review suggests that nonunions of radius and ulnar diaphyseal segmental defect of up to six cm can be treated with autologous tricortical bone grafts. Iliac grafts, which are longer than this, make it difficult to obtain adequate compression due to the curve of the bone.[5]

Nicoll described the technique with a block of cancellous iliac bone graft fixed at both ends with plate and screws and secured with cancellous slices at both junctions.[11]

We modified this procedure by increasing the length of a triccorticocancellous graft by (1cm) more than the defect and tappering (5mm) on both ends to allow impaction of both ends inside medulla to increase the size of bone contact and allow optimal compression of both ends and the cortical surface of the iliac graft was placed opposite the plate to allow secure compression without crushing. Before placement of the graft we confirmed that both ends of the recipient fracture site has sufficient blood supply by removing the atrophic ends till normal bone is seen which bleeds freely.

This technique of grafting is simple; it provides stability to fracture as well as bone graft. The presence of cortical bones on three sides allows good compression at both graft junction without crushing of cancellous block and enough strength till it is incorporated. The thin cortical bone on the both sides permits invasion of the periosteal circulation early. Abundance of the cancellous bone allows early graft incorporation and permits early fracture healing. so, the technique serves in three ways, i.e., internal fixation, defect bridging, and osteogenesis promoter. [3]

This study included 18 forearm bones with mean gap of 5.4 cm with a mean duration of non union about 14.7 months in 12 patients who had mean age of 34 years. The interval between index procedure and management of non union was 16 months. After treatment with modified Nicoll technique with tapered graft, the mean duration of union was 18 weeks. The mean elbow flexion was 121 and extension of -5 degrees. The mean wrist flexion was 65 and extension 60 degrees. The mean supination was 66 and pronation 72 degrees. The final Anderson score was outstanding in 6 patients, good in 3 patients and fair in another 3 patients. The VAS score was 2. There was some complications reported in form of stiff fingers, infection, muscle herniation and delayed union.

Gupta and Kumar used modifefd Nicoll technique for management of gap non union in dispahyseal forearm fractures. An overall of 38 forearm bones in 23 cases with a gap of 1.5-7.5 cm were treated by tricortical bone graft under compression with intramedullary nail fixation. Time of presentation since the original trauma varied from 9 months to 84 months. The mean duration of fracture healing was 17.5 weeks. Two bones had union only at one host graft junction and did not show any sign of callus formation up to 9 months. Obstacles observed were the fulmenant of infection and herniation of the muscles at the donor site. 6 cases had weak grip strength in comparison with the other hand and 3 cases had wrist and fingers stiffness. Only one case had herniation of muscles at the donor site. 10 patients had full (>150°), 5 patients had 80 to 150° , and rest 8 patients had <80° range of supination/ pronation movement. [5]

Adani et al [15] used vascularized fibular graft for management of large diaphyseal non union of both bones forearm fractures. The study included 12 patients with segmental bone defects following forearm fracture and were treated with vascularized fibular

grafts: six males and six females, aged 39 years on average. The reconstructed site was the radius in eight patients and the ulna in four. The length of segmental bone defect ranged from 6-13 cm. In four patients, the vascularized fibula was used .To achieve fixation of the grafted fibula, plates were .

Used in 10 cases, and screws and Kirschner wires in 2. In the last 2 cases, an external fixator was used to allow immobilization of the extremity. The period of follow up ranged from 10-93 months. Eleven grafts were successful. The mean period to obtain radiographic bone union was 4.9 months (range, 2.58 months). They concluded that the vascularized fibular graft was indicated in patients with intractable nonunions where conventional bone grafting has failed or large bone defects, exceeding six cm, are detected in the radius or ulna.[15]

Boussakri et al [16] evaluated the functional and radiological results of surgical management of diaphyseal aseptic nonunion of the radius & ulna, with bone grafting, decortication and plate fixation. A series of 21 cases (26 nonunions) was retrospectively studied, the average age was 35 years with a mean of 31,59 years (range 12-44 years) . The fractures included isolated radius (n=6) and ulna (n=10), and both radius and ulna (n=5). The Grace and Eversmann score was used to assess their results. 15 patients had very good results, 5 patients good and one patient average. Healing of the two bones was achieved in 6.2 months. [16]

Some authors report the importance of the management of forearm fractures nonunion by using intramedullary nailling. However, technique offers relative stability and absence of rotation control. The locked nail appeared to be indicated only for hypertrophic diaphyseal nonunion without iliac bone graft and not in atrophic non union. [17]

Regarding ilizarov technique for management of diaphyseal forearm nonunion with bone defects, this type of treatment has the advantages of no septic risks and periosteal devitalization, but in reality, it suffers from some complications such as: difficulties in blocking rotation, gaining an anatomical reduction, bad fixation and insufficient compression, as well as complications including vascular and nerve injury during the installation of sheets. [18]

This standard technique using a bone plate and an iliac graft is less effective in the management of long defects. It is particularly less effective in bone defects over 6 cm and which have operational difficulties for using iliac graft so as to get sufficient compression and a normal length due to the physiological bowing of the bone. [6]

Ring et al [1] showed that a non-vascularized bone graft led to union in the case of atrophic nonunion with bone defect up to six cm while, Dos Reis et al [10] showed, in a sequence of 31 patients, that management with corticocancellous iliac bone graft and fixation with a plate for hypertrophic and atrophic nonunion led to excellent functional results. Yet, the treatment still controversial for segmental bone defects ranged between 6cm and 10.5 cm. [19]

Davey et al highlighted on the limits of the use indications concerning non-vascularized bone graft for bone gaps more than 6 cm. In order to be successful, this surgical procedure depends on the healing of corticocancellous iliac bone graft. [6]

Conclusion

Surgical management of non-union with decortication, tricorticocancellous iliac bone graft and stabilization with compression plate has achieved satisfactory results in our series. Yet, the best management of nonunion still the preventive treatment with an proper management and care of the fractures of the forearm.

Our results are in agreement with other reports printed in the literature. The our study limitation is the little number of patients, the small follow up period and absence of a control group. The choice of bone graft is remain a controversial subject.

References

1. Ring D, Allende C, Jafarnia K, Allende BT, Jupiter JB. Ununited diaphyseal forearm fractures with segmental defects: plate fixation and autogenous cancellous bone-grafting. JBJS. 2004;86(11):2440-5.
2. Wei SY, Born CT, Abene A, Ong A, Hayda R, DeLong WG. Diaphyseal forearm fractures treated with and without bone graft. Journal of Trauma and Acute Care Surgery. 1999;46(6):1045-8.
3. Kloen P, Buijze GA, Ring D. Management of forearm nonunions: current concepts. Strategies in Trauma and Limb Reconstruction. 2012;7(1):1-11.
4. Kloen P, Buijze GA. Treatment of proximal ulna and olecranon fractures by dorsal plating. Operative Orthopädie und Traumatologie. 2009;21(6):571-85.
5. Gupta DK, Kumar G. Gap nonunion of forearm bones treated by modified Nicoll's technique. Indian journal of orthopaedics. 2010;44(1):84.
6. Davey P, Simonis R. Modification of the Nicoll bone-grafting technique for nonunion of the radius and/or ulna. The Journal of bone and joint surgery British volume. 2002;84(1):30-3.
7. Ring D, Tavakolian J, Kloen P, Helfet D, Jupiter JB. Loss of alignment after surgical treatment of posterior monteggia fractures: salvage with dorsal contoured plating1. The Journal of hand surgery. 2004;29(4):694-702.
8. Ring D, Jupiter JB, Gulotta L. Atrophic nonunions of the proximal ulna. Clinical orthopaedics and related research. 2003;409:268-74.
9. Arredondo-Gómez E. Treatment of forearm nonunion with iliac crest graft and a Hunec nail. Acta Ortopédica Mexicana. 2005;19(s1):28-33.

10. dos Reis FB, Faloppa F, Fernandes HJA, Albertoni WM, Stahel PF. Outcome of diaphyseal forearm fracture-nonunions treated by autologous bone grafting and compression plating. Annals of surgical innovation and research. 2009;3(1):5.
11. Nicoll E. The treatment of gaps in long bones by cancellous insert grafts. The Journal of bone and joint surgery British volume. 1956;38(1):70-82.
12. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. JBJS. 1976;58(4):453-8.
13. Anderson LD, Sisk D, Tooms R. Compression-plate fixation in acute diaphyseal fractures of the radius and ulna. The Journal of bone and joint surgery American volume. 1975;57(3):287-97.
14. Cella DF, Perry SW. Reliability and concurrent validity of three visual-analogue mood scales. Psychological reports. 1986;59(2):827-33.
15. Adani R, Delcroix L, Innocenti M, Marcoccio I, Tarallo L, Celli A, et al. Reconstruction of large posttraumatic skeletal defects of the forearm by vascularized free fibular graft. Microsurgery: Official Journal of the International Microsurgical Society and the European Federation of Societies for Microsurgery. 2004;24(6):423-9.
16. Boussakri H, Elibrahimi A, Bachiri M, Elidrissi M, Shimi M, Elmrini A. Nonunion of Fractures of the Ulna and Radius Diaphyses: Clinical and Radiological Results of Surgical Treatment. Malaysian orthopaedic journal. 2016;10(2):27.
17. Hong G, Cong-Feng L, Hui-Peng S, Cun-Yi F, Bing-Fang Z. Treatment of diaphyseal forearm nonunions with interlocking intramedullary nails. Clinical Orthopaedics and Related Research. 2006;450:186-92.
18. Ilizarov G, Kaplunov A, Degtiarev V, Lediaev V. Treatment of pseudarthroses and ununited fractures, complicated by purulent infection, by the method of compression-distraction osteosynthesis. Ortopediia travmatologiiai protezirovanie. 1972;33(11):10.
19. Moroni A, Rollo G, Guzzardella M, Zinghi G. Surgical treatment of isolated forearm non-union with segmental bone loss. Injury. 1997;28(8):497-504.