

A Comparative Study between Intramedullary Nailing Versus Plating for the Treatment of Diaphyseal Nonunited Fractures

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Abstract: Nonunion is one of the serious complications of fractures and it occurs when the fracture has little or no potential to heal. Operative treatment is usually the treatment of choice for established nonunion fractures and this can be either with intramedullary locking nails, plates and screws, or ilizarov technique. The aim of this study is to assess the value of union among patients complaining of nonunion fractures treated by intramedullary nailing or plating as regard rate of union and complications, and reporting important risk factors affecting outcome. In this retrospective comparative study conducted between march 2018 and February 2019 in Al-Nu'man Teaching Hospital and Baghdad private hospitals. 30 patients with history of nonunion fractures treated by either intramedullary nailing or plate and screws were followed up until union occurred (3-6)months. Group1(15 patients) male(10) female (5) (mean age, 34.87+13.061)years treated by locked plate with bone graft. Group 2 (15 patients)male(11)female(4)(mean age, 43.87+16.656) years treated by locked intramedullary nailing with or without bone graft. The results of both groups regarding union were compared. All patients in both groups had union as a final outcome after procedure of fixation, the time of union ranged between (2-5)months, the mean time of union for patients treated with plate and screws was (3.60) months and was less than that for patients treated with intramedullary nails which was (4.13) months, this difference was clinically significant. the period of follow up was between (3-6)months. In conclusion the locked plates and screws and intramedullary locked nails have a good final outcome regarding union for nonunion fractures treated by these procedures of fixation, but union in patients treated with locked plate and screws was faster than patients treated with locked intramedullary nails.

Keywords: Nonunion fractures, intramedullary nailing, plate and screws

1. Introduction

Nonunion :is one of the late complications of fractures, it was defined as permanent failure of fracture to unite and show no evidence of a further union, also was defined as a fracture that is a minimum of 9 months post occurrence and is not healed and has not shown radiographic progression for 3 months. This definition has been criticized because different bones has different healing time, some show potential of healing but some does not, 9 months waiting for every bone before starting treatment as nonunion is impractical. The designation of nonunion is currently made when the surgeon believes that the fracture has little or no potential to heal.[1,2,3]

There are two types of nonunion:

- 1) hypertrophic nonunion :the bone ends enlarge suggesting that osteogenesis is still active but not quite capable of bridging the gap, so it is vascularized, callus formation present on x-ray and this subdivided into elephant foot abundant callus, horse hoof less abundant callus.[4,5,6]
- 2) atrophic nonunion : osteogenesis seems to have ceased, the bone ends are tapered or rounded with no suggestion of new bone formation, no callus on x-ray.[5]

Causes of nonunion include inadequate immobilization, poor blood supply and infection.

Risk factors for nonunion include:

- 1) Patient related factors like :diabetes, poor nutrition smoking, steroid therapy radiation therapy anticoagulant therapy, high alcohol intake, old age
- 2) Injury related factors like: infection, open injuries, soft tissue interposition, bone loss resulting in gap,

compromised blood supply following injury to nutrient artery, stripping injury to muscle and periosteum, severe comminution due to high energy trauma.[7]

- 3) Treatment related factors: inadequate immobilization, distraction of fragment from traction or internal fixation, malposition of fragments, implant failure. [7]

In regard the diagnosis of nonunion usually the patient has a history of painless abnormal movements at fracture site, pain may present at fracture site but in established nonunion it is pain free, the patient also unable to bear weight, there may be symptoms of infection.

On examination there is abnormal movements at fracture site, deformity, evidence of infection (sinuses, sclerotic and sequestered bone fragments), soft tissue abnormality (atrophied skin scar, pigmentation).

Investigations like complete blood count, biopsy, wound swab, pus c/s may indicate presence of infection.[6,7]

Radiologic evaluation for nonunion usually standard radiographs are often diagnostic, 45 degree oblique views, stress x-ray can increase diagnostic accuracy, sometimes radionuclide scanning, CT scan and MRI may be required for diagnose nonunion.

Treatment of nonunion is either non operative treatment or operative treatment. In non operative as in hypertrophic nonunion functional bracing may be sufficient to induce union, but splint age often needs to be prolonged, pulse electromagnetic fields and low frequency, pulsed ultrasound can be used to stimulate union, bone marrow and bone morphogenic protein injection.[4,8,9,10,11,12,13,14]

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In established nonunion non operative treatment rarely helpful. Operative treatment is usually the treatment of choice in nonunion, hypertrophic nonunion in the absence of deformity very rigid fixation (intramedullary locking plates or dynamic compression plates) may lead to union without requiring bone graft.

While with atrophic nonunion fixation alone is not enough, fibrous tissue in the fracture gap as well as the hard sclerotic bone ends are excised and bone grafts are packed around the fracture.

Types of bone grafts used are crest, it is the gold standard for filling bone defects. (vascularized fibular graft) ,(cancellous allograft material) is osteo conductive and has been used successfully, but problems of risk of viral transmission limits its usefulness, -(synthetic bone graft substitutes): consist of coralline hydroxyapatite, calcium sulfates and calcium phosphates as performed implant and as cements, none of these materials provides enough structural support for unprotected weight bearing.[9,15,16,17,18]

Intramedullary nails Also known as intramedullary rod, or inter-locking nail or Kuntsher nail, it is used in treatment of tubular bone fractures mainly in femur and tibia. Compression of the nonunion can be achieved by interlocking the IM nail distally and applying a reverse impaction force or by dynamically locking the nail. Some IM nail systems provide an internal compression system in which the nail is first locked distally, then a proximal interlocking screw is placed in the dynamic side of the oval interlocking hole. [19,20,21]

Plate and screw is one of the types of implants used to treat fractures. Blade plates offer improved fixation compared with standard compression plates. Locked plate fixation offers biomechanical advantages compared with fixation with non locking plates as with blade plates, the use of a locked –plate construct is beneficial in achieving fixation of short bone segments. Plates have five different functions: 1-neutralization 2- compressing 3- buttressing 4- tension-band 5- antiglade.[22]

Research Objectives

To assess the value of union among patients complaining of nonunion fractures treated by intramedullary nailing or plating as regard rate of union and complications, and reporting important risk factors affecting outcome.

2. Materials and Methods

This retrospective comparative study conducted between March 2018 and February 2019 in Al Nu'man Teaching Hospital and Baghdad private hospitals. We obtained informed consent from each patient. 30 patients of both sex, of different age groups and of different durations of nonunion fractures treated by either intramedullary nailing or plate and screw were followed up until union occur. The data collected from each patient according to special questioner form. Group 1: (15 patients), male (10), female (5) (mean age, 34.80 ± 13.061) years treated by plate with locking screw with bone graft in all patients. Group 2: (15 patients), male (11), female (4) (mean age, 43.87 ± 16.656)

years treated by intramedullary nailing with locking screw, 12 patients with graft, 3 patients without bone grafting. Type of fractures were categorized as closed or compound fractures. Site of fractures were categorized as tibia-fibula bone intact or not, femur, humerus. Type of nonunion were categorized into: hypertrophic & atrophic non unions.

Certain factors related to nonunion such as general factors like smoking ,alcohol consumption, diabetes mellitus, peripheral vascular diseases, heart failure, or local factors like infection, implant failure , inadequate immobilization, direct reduction, gap between fracture fragments categorized into: yes or no.

Type of primary procedure categorized into: IM Nail, plate and screw, cast, external fixator.

Procedure of operation categorized into: one stage or two stage operation.

Type of fixation categorized into plate with locking screw or intramedullary nail with locking screw. In all patients treated with plate and locking screw bone graft were added, while only in 12 patients treated with intramedullary nail and locking screw bone graft were added.

Outcome of operation categorized into: union or nonunion, if union after how many months.

Surgical procedures

Internal fixation is the preferred option for nonunion, this should provide sufficient stability for fracture, healing with minimum complications. The choice of internal fixation depends on type of non union, the condition of soft tissue envelope and bone, the size and position of the bone fragments, and the size of the bone defect, plate and screw without bone grafting usually is adequate for hypertrophic non unions, if the bone is not osteoporotic and the fragments are large enough for firm screw fixation intramedullary nailing especially interlocked nailing, is useful in nonunions of long bones such as tibia, femur and humerus. Therequirements common to all successful techniques are biomechanical stability and a biological vitality of the bone, this can be obtained through good reduction, sufficient bone grafting and firm stabilization of the fragments.

Operations done under general anesthesia or spinal anesthesia, complete setup of instruments and implants are prepared, if the alignment of the nonunion fracture is acceptable, or closed reduction can be obtained, the technique of closed interlocking intramedullary nail was performed without exploring the fracture site in 3 patients, bone grafting usually is not required as in hypertrophic non unions. When an open technique was required usually incisions done according to fracture sites, the primary fixation implants are removed, scar tissue around the nonunion must be excised so that the graft can be covered by relatively normal tissue, the fragments were mobilized, preserving their soft tissue attachments as much as possible, their rounded ends are resected so that the contact is maximal, their medullary canals are cleared of fibrous tissue to aid in medullary osteogenesis, and they are apposed as

closely as possible and decortication of bone ends and fracture sites done, anatomical reduction and fixation with new implant as locked plate and screws or with larger size intramedullary locking nails in case of non unions following primary procedures of fixation accompanied with bone grafting cancellous autogenous bone graft, mostly obtained from the iliac crest. preoperatively prophylactic intravenous broad spectrum antibiotics were used. Patients with history of infection treated in two stage operation, first stage the primary implants removed and left until the infection completely subside then in second stage new implants inserted with bone graft. The patients are kept in hospital for 1-2 days post operatively for observations, stitches removed after 10-14 days, the patients instructed after discharge to attend for follow up at regular periods every 3 weeks. All patients were followed up for a range of 3-6 months until union occurred based on clinical findings, partial weight bearing until radiological evidence of union (callus traversing fracture sites) (figure 1&2)

3. Results

The mean age of the sample was (39.33 ± 15.412) years ranging from (12-80) years, the mean age of patients treated by locked plate and screw was (34.80 ± 13.61) years, the mean age of patients treated by locked intramedullary nail was (43.87 ± 16.656) years.

There were 21(70%) male patients and 9(30%) female patients as shown in fig. 1, the mean age of male patients was (37.81 ± 13.182) years, while the mean age of female patients was (42.89 ± 20.156) years.

In regard the type of fracture there were 21(70%) patients with history of closed fracture and 9(30%) patients with history of compound fracture, the mean time of union after procedure of fixation for closed fractures was $(3.86 \pm .655)$ months and the mean time of union for compound fractures was $(3.89 \pm .601)$ months, the P value was 0.9.

Regarding the site of fracture there were 14(46.7%) patients with fracture femur (in 5 patients nonunion site was in proximal 3rd of femoral diaphysis, in 6 patients it was in middle 3rd and in 3 patients nonunion site was involving the distal 3rd of femur), 7 (23.3%) patients with fracture tibia fibula bone not intact, 5 (16.7%) patients with fracture tibia fibula bone intact and 4 (13.3%) patients with fracture humerus.

Regarding the pattern of fracture, there were 13(43.3%) patients with oblique fracture, 8(26.7%) patients with transverse fracture, 5(16.7%) patients with comminuted fracture and 4(13.3%) patients with spiral fracture as shown in Figure 3.

Regarding the type of nonunion there were 7(23.3%) patients with hypertrophic type of nonunion and 23(76.7%) patients with atrophic type of nonunion as shown in Figure 4, the mean time of union for patients with hypertrophic type was $(3.57 \pm .787)$ months and the mean time of union for patients with atrophic type was $(3.96 \pm .562)$ months, the P value was

There were 12(40%) patients with history of smoking and 18(60%) patients with no history of smoking as shown in, 58.3% of smoker patients with history of smoking 2 packs/day, the mean time of union for smoker patients was (4.17 ± 0.389) months and the mean time of union for nonsmoker patients was (3.67 ± 0.686) months, the P value was 0.03

There were 7(23.3%) patients with history of diabetes mellitus and 23(76.7%) patients with no history of diabetes mellitus, the mean time of union for diabetic patients was $(4.14 \pm .378)$ months and the mean time of union for non diabetic patients was $(3.78 \pm .671)$ months, the p value was 0.189.

There were 5(16.7%) patients with history of infection before nonunion and 25(83.3%) patients with no history of infection, for those with history of infection 2 patients had pus, 2 patients had active and 1 patient with serous discharge, the mean time of union for patients with history of infection was $(4.60 \pm .548)$ months and the mean time of union for patients with no history of infection was (3.72 ± 0.542) months, the P value was 0.003. There were 21(70%) patients with history of 1st implant failure and 9(30%) patients with no history of implant failure for those with history of failure the great percentage 33.3% had history of failure after 24 weeks. In regard inadequate immobilization there were 19 (63.3%) patients with history of inadequate immobilization and 11(36.7%) patients with no history of inadequate immobilization, the mean time of union for patients with history of inadequate immobilization was $(4.00 \pm .471)$ months and the mean time of union for other patients was $(3.64 \pm .809)$ months, the P value was 0.129. There was 1(3.3%) patient with history of alcohol consumption and there were 29(96.7%) patients with no history of alcohol consumption.

There was 1(3.3%) patient with history of peripheral vascular disease and there were 29(96.7%) patients with no history of peripheral vascular disease.

There were 22(73.3%) patients with history of gap (less than 2 cm) between fracture fragments, these patients required bone grafting and there were 8(26.7%) patients with no history of gap between fracture fragments. There were 24(80%) patients with history of imperfect reduction and 6(20%) patients with no history of imperfect reduction during the first primary procedure.

Regarding the type of primary procedure, there were 12(40%) patients with history of plate and screw, 8(26.7%) patients with locked medullary nail, 6(20%) patients with external fixator and 4(13.3%) patients with cast procedure.

patients treated with one stage operation and 7(23.3%) patients treated with two stage operation, patients with history of infection treated by two stage operation, in 1st stage the primary implants were removed and the patient left until the infection completely subside then in 2nd stage new implant inserted, the mean time of union for patients treated with one stage was $(3.78 \pm .600)$ months and the mean time of union for patients treated with two stage was $(4.14 \pm .690)$ months, the P value was 0.19.

Regarding the procedure of fixation , there were 15(50%) patients treated with plate and screws and 15(50%) patients treated with locked intramedullary nail as shown in Figure 3-5, the mean time of union for patients treated with plate and screw was $(3.60 \pm .737)$ months and the mean time of union for patients treated with locked intramedullary nail was $(4.13 \pm .352)$ months , the P value was 0.017 and this was clinically significant. Regarding the time of union, there were 21(70%) patients had union within 4 months, 5(16.7%) patients had union within 3 months, 3(10%) patients had union within 5 months and 1(3.3%) patient had union within 2 months. In regard complications , shortening 1-2 cm encountered in 2 patients, superficial wound infection were occurred in 4 patients and controlled by antibiotics alone and in 1 patient with nonunion of the tibia mild varus angulation was occurred. There were no important complications such as broken implant ,axial or rotational mal alignment or deep seated infection.



Figure 1: The patient with nonunion fracture femur treated primarily by locked intramedullary nail.



Figure 2: The same patient with union after fixation with locked plate

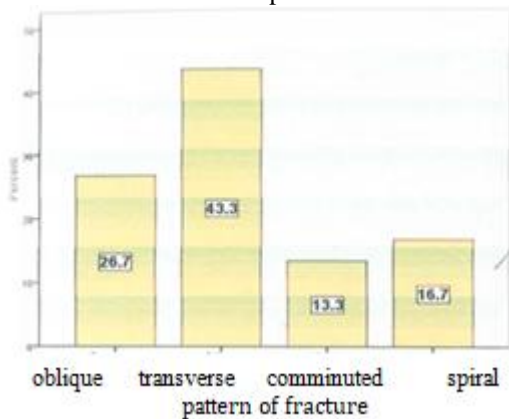


Figure 3: Distribution of patients according to pattern of fracture

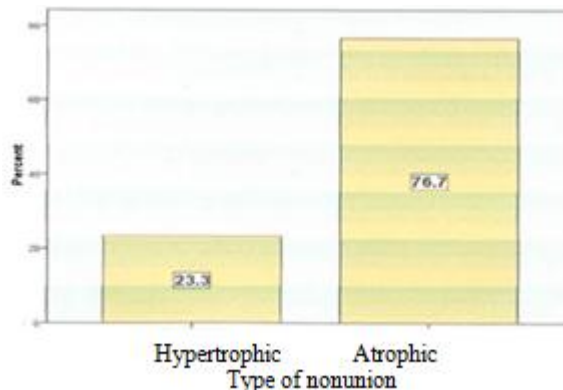


Figure 3: Distribution of patients according to type of nonunion

4. Discussion

Nonunion is one of the serious complications of fractures, it is permanent failure of fracture to unite, operative treatment is usually the treatment of choice in established nonunion fractures, there are a variety of implants used in operative refixation of nonunion fractures, locked plate and intramedullary locked nails are good alternatives together with bone grafting.[1]

In this study, there were 21(70%) male patients and 9(30%) female patients, this male dominance may be due to that male patients are more prone to road traffic accidents which are common causes of fractures which may lead to nonunion.

There were 14(46.7%) patients with fracture femur, 7(23.3%) patients with fracture tibia fellow bone not intact, 5(16.7%) patients with fracture tibia fellow bone intact, 4(13.3%) patients with fracture humerus, this femur dominance may be due to that fracture femur is usually a common fracture of adults and result from high energy injuries as in road traffic accidents.[4]

There were 13(43%) oblique pattern of fracture, 8(26.7%) transverse pattern, 5(16.7%) comminuted pattern and 4(13.3%) spiral pattern of fracture, this may be due to that oblique and transverse fractures are more often due to angulation or direct violence which are particularly common in road traffic accidents.[4]

There were 12(40%) smoker patients and 18(60%) non smoker patients, the mean time of union for smoker patients was (4.17 ± 0.389) months and the mean time of union for non smoker patients which was $(3.67 \pm .686)$ months, this may indicate that smoking have a negative effect on bone healing and it significantly delay fracture healing.[9]

It was found that the mean time of union for diabetic patients was (4.14 ± 0.873) months and was more than the mean time of union for non diabetic patients which was (3.78 ± 0.671) months , this may indicate that diabetes is one of the systemic factors which may affect bone healing.[6]

It was found that the mean time of union for patients with history of infection was (4.60 ± 0.548) months and was more than the mean time of union for patients with no history of

infection which was (3.72 ± 0.542) months, the P value was 0.003 which was clinically significant, this indicates that infection affect bone healing.[7]

We found that certain factors like first implant failure which was found positive in 21(70%) of patients, in adequate immobilization which was positive in 19(63.3%) of patients, gap between fracture fragments which was positive in 22(73.3%) of patients and imperfect reduction which was positive in 24(80%) of patients, this indicates that these local factors may affect bone healing.[7]

We found that the mean time of union for patients treated with plate and locking screw was (3.60 ± 0.737) months and was less than the mean time of union for patients treated with intramedullary nails and locking screws which was (4.13 ± 0.352) months, the P value was 0.017 and this was clinically significant, this may be due to the fact the mean age of patients treated with plate and locking screws was (34.80 ± 13.61) years and was less than the mean age of patients treated with intramedullary nails and locking screws which was (43.87 ± 16.655) years and may be due to that plates and locking screws had faster duration regarding union than intramedullary nails and locking screws because bone graft used in all patients treated with plate and locking screws, while bone graft not used in all patients treated with intramedullary nails with locking screws.

5. Conclusions

In conclusion we feel that both plates with locking screws and intramedullary nails with locking screws are good values for the operative treatment of nonunion fractures with no significant complications, however we found that the mean time of union for patients treated with plates and locking screws was less than that for patients treated with intramedullary nails with locking screws.

6. Recommendation

- 1) Plates with locking screws and intramedullary nails with locking screws are methods of choice for operative treatment of nonunion fractures, their clinical outcome are good with minimum rates of complications.
- 2) We recommend further studies with longer duration of follow up and larger sample size for evaluation of successful rates of union and assessing any complications.

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