

Intramedullary nail fixation for the treatment of simple forearm fractures in military combatants

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Research

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Abstract

Background: Most of forearm fracture in military combatants are simple fracture. The traditional procedure for adult forearm fracture is open reduction and plate osteosynthesis. However, plate fixation do have the defect of nonunion, stress shielding, skin irritation. Intramedullary nail is believed to be an alternative treatment of adult forearm fractures. However, whether simple forearm fractures in military combatants could be successfully treated by intramedullary nail is not clear.

Methods: Patients of military combatants with diagnosis of simple forearm fracture treated by intramedullary nail fixation were identified from 1st January 2016 to 31st November 2018 in this retrospective study. General information of the patients, time of follow-up, time of fracture union post-operation, complications, rotation activity and DASH score 12 month post-operation were recorded to figure out the clinical outcome of simple forearm fracture treated by intramedullary nail in military combatants.

Outcome: Twenty male patients were identified in this retrospective study, with average age of 26.5 years old (range 18-36). Fourteen forearm fracture happened in right side and the rest six happened in left side. Single ulna fracture happened in 11 cases, single radius fracture happened in 4 cases, both forearm fracture happened in 5 cases. Classifications of the 20 patients were all OTA type A. All 20 patients got followed, with mean follow-up time of 15.8 months (range 12-18). All patients got fracture union successfully. Average time of fracture union was 2.6 months (range 2-4 months). Partially rupture of extensor pollicis longus tendon happened during operation in one patient and 3 months post-operation in another patient. One patient with both forearm fractures showed linear ossification of interosseous membranes. Average pronation activity 12 months post-operation was 86.9 degrees (range 80-90), average supination activity 12 months post-operation was 86.3 degrees (range 60-90). Average DASH score 12 months post-operation was 6.5 (range 0-37).

Conclusion: This respective study demonstrated that intramedullary nail achieved excellent results in the treatment of simple fracture of forearm in military combatants.

Trial Registration : Not applicable

Introduction

As the mechanism of forearm fracture in military combatants is mostly fall over or collision, majority of these fracture are simple fracture. Forearm fracture is treated as intra-articular fracture for the special anatomy and rotation function. Adult forearm fracture, single or both, is treated by surgical fixation routinely. The golden procedure for adult forearm fracture is open reduction and plate osteosynthesis for reasons of precise anatomical restoration and early rehabilitation. Excellent results is reported by standard surgical technique. However, open reduction and plate osteosynthesis do have some defects. First, periosteal stripping increases the risk of nonunion[1]. Second, stress shielding by plate results in 11-20% refracture following plate removal[2]. Third, widely exposures and disrupt the blood supply result in

0.8-2.3% of infection[1] and fourth, skin irritation happens commonly after plate fixation of ulnar fracture[3]. Forearm fracture was regarded as contraindication for intramedullary nail treatment for the reasons of un-anatomical reduction and insufficient rotational stability [4].

A certain number of clinical reports showed satisfied results of intramedullary nail for the treatment of adult forearm fractures[1-3.5]. Lee YH[1] reported 92% excellent or good result in 27 forearm fracture patients treated by intramedullary nail fixation. Ozkaya U [5] compared intramedullary nailing and plate osteosynthesis in 42 adult forearm fracture, 22 treated with open reduction and plate osteosynthesis and 20 with closed reduction and interlocking intramedullary nail fixation. The result showed intramedullary nailing treatment achieved shorter time of fracture union.

Whether simple forearm fracture in military combatants could be treated by intramedullary nail is seldomly discussed. We respectively studied military combatants patients with diagnosis forearm fracture treated by intramedullary nail in an attempt to figure out **(i)** functional outcome of simple forearm fracture treated by intramedullary nail fixation; **(ii)** complication of intramedullary nail treatment. **(iii)** Introduce the technique of intramedullary nail fixation for simple forearm fracture in military combatants.

Patients And Methods

Inclusion and exclusion criteria

Patients were selected using the following inclusion criteria: **(i)** Military combatants patient with age ≥ 18 years old and ≤ 60 years old. **(ii)** close OTA type A [6] forearm fracture treated by intramedullary nail. **(iii)** patients with intact clinical and radiographic data. **(iv)** patients had a minimum 12-months follow-up period. The exclusion criteria included: **(i)** forearm fracture combined with vascular/nerve injury/combined ipsilateral upper extremity fracture. **(ii)** forearm fractures treated with plate fixation. **(iii)** Pre-history of forearm fracture.

Study Design

This retrospective study got approved by Ethics Committees of the hospital (LZEC2019-YW-0126). Military combatants patients with diagnosis of OTA type A forearm fracture treated by intramedullary nail in our institution between 1st January 2016 to 31st November 2018 were reviewed. General information of the patients, time of follow-up, time of fracture union post-operation, complications(infection/nonunion/cross-union/tendon rupture /vascular, nerve injury), rotation activity and DASH score [7] 12 month post-operation were respectively studied.

Surgical technique

Forearm intramedullary nails made by Acumed,USA were used in this respective study. Diameters of both ulna and radius nails have 3.0mm and 3.6 mm in size. Length of radius nail range from 190mm to 230 mm in 2-cm increments. Length of ulna nail range from 210 to 270 mm in 2-cm increments. Pre-operation

measure of diameter and length of ulnar and radius was carried out on the X-ray to make sure the fracture could be treated by intramedullary nails. Radius nail is designed as one single 3.5-mm-diameter interlocking holes in distal and paddle-blade-tip design in proximal for the aim of anti-rotation and length stability. Ulna nail is designed as three 3.5-mm-diameter interlocking holes in proximal and paddle-blade-tip design in distal. This requires distal of ulna nail and proximal of radius nail must reach the metaphysis of ulna and radius to achieve stabilization. Acumed forearm nails are solid nails, so nailing following guiding wire is not possible. Maintaining reduction of forearm fracture is needed during reaming and nailing. Close reduction could be easily achieved in simple ulna fracture because ulna could be touched subcutaneously. Open reduction by small incision is occasionally need in radius fracture. In both ulna and radius fracture, ulna was fixed firstly. Reduction and fixation of ulna fracture would be helpful for radius fracture reduction.

Under general anesthesia or brachial plexus anesthesia, patients were placed supine with tourniquet control on a radiolucent operation table. For ulna fracture, forearm was placed pronation with elbow 90-degree-flexion on the operation table. A guiding wire was drilled to canal of ulna from the tip of the olecranon process percutaneously. Once X-ray confirmed guiding wire intermediately in canal, a 1-cm longitudinal incision is made along the guiding wire. After vertical split of triceps, opening drill was used to create the entry hole following guiding wire. Hand-held reamers were used to achieve canal preparation for the intramedullary nail . The length was measured by the calibrated of reamer. Then ulna nail was then placed to fix ulna fracture.

For radius fracture, forearm was placed pronation on the operation table. A 2cm longitudinal incision is made along the ulna side of Lister's tubercle. Extensor pollicis longus tendon was protected by traction to ulna side. Awl was used to create entry hole just ulnar to the Lister tubercle. Hand-held reamers and nail placing were similarly as ulna fracture with flexion of wrist. Radius fracture close reduction could not be achieved in one patient with both forearm fracture and one with single radius fracture, a 3cm incision along Henry approach was used for exposure and reduction.

Post-operation treatment:

For the first 48 hours post-operation, forearm was elevated by pillow with ice to reduce swelling. Then a well-molded long arm plaster was applied to maintain forearm and wrist in supination for 6 weeks until callus is observed. Active forearm supination and pronation exercises were implemented after removal of plaster. A-P and lateral view X-ray of forearm was taken once each month for the first three month post-operation and at 6 month and 12 post-operation. Complications(tendon,vascular, nerve injury /infection/ fascia compartment syndrome /nonunion/cross-union), time of fracture union postoperation were recorded. Rotation activity and DASH (Disability of Arm Shoulder and Hand) score[7] were recorded at 12 month post-operation follow-up.

Results

Twenty male military combatants patients were identified in this retrospective study. All 20 patients got followed, with mean follow-up time of 15.8 months (range 12-18). All patients got fracture union successfully. Average time of fracture union post-operation was 2.6 months (range 2-4). Partially rupture of extensor pollicis longus tendon happened during operation in one patient when awl was used to make an entry hole and 3 months post-operation in another patient as a result of nail irritation. The former patient was treated by repair of extensor pollicis longus tendon during operation and the latter by implant remove and tendon repair, as fracture union was confirmed. No vascular/nerve injury, infection, fascia compartment syndrome, nonunion or cross-union happened. One patient with both forearm fractures showed linear ossification of interosseous membranes, but the rotation activity was not affected. Average pronation activity 12 months post-operation was 86.9 degrees (range 80-90), and Average supination activity 12 months post-operation was 86.3 degrees (range 60-90). Average DASH score 12 months post-operation was 6.5 (range 0-37).

Discussion

Forearm fracture is one of the common injury during drill and training of military combatants. As the mechanism of forearm fracture in military combatants is mostly fall over or collision, majority of these fracture are simple fracture. For the past two decades, forearm intramedullary nail showed excellent clinical outcomes in adult diaphyseal forearm fractures [1-3,5]. However, forearm fracture in military combatants could be treated by Intramedullary nail have not been reported [4]. We focus on the simple forearm fracture of military combatants trying to figure out whether intramedullary nail could be listed as an option. Our study showed excellent result of intramedullary nail in the treatment of simple forearm fracture. We believe the reasons for the success should be attributed to length stability, which was supplied by nail fixation and fragment contact after reduction, and rotation stability, which was supplied by plaster and paddle-blade-tip design of the nail.

Rotation function is the most important reason why forearm fracture is treated as intra-articular fracture. Open reduction and plate osteosynthesis could achieve precise anatomical restoration of forearm fracture. Insufficient rotation stability is the major concerns of forearm intramedullary nail in the treatment of forearm fracture. However, our results showed excellent rotation activity of forearm fracture in military combatants treated by intramedullary nail. We believe there are three reasons for rotation stability. First, as long as the distal of nail reaches the metaphysis of ulna and radius, Acumed forearm intramedullary nail could maintain both length stability and rotational stability with the help of plaster. Second fracture pattern may be an influence on stability too, as the type of forearm fractures in this study were all simple fracture. Contact of fracture segment would enhance stability once simple fracture is contacted. Third, long arm plaster was applied to maintain forearm and wrist in supination for 6 weeks postoperation greatly helped to maintain the rotation stability.

Another concern for forearm nails is radioulnar synostoses, which could be as high as 9.4% after plate fixation [9]. Both forearm fracture at same level, interosseous membranes damage and plaster immobilization are risk factors for post-trauma radioulnar synostoses. Wedge fractures of OTA type B3

also demonstrated high risk of synostosis when intramedullary nail was used for the treatment[10]. Hematoma caused by reaming, if located at damaged interosseous membranes, may result in radioulnar synostoses too. Linear ossification of interosseous membranes happened in one patient with both forearm fracture at same level. The reason may be attributed to haematoma located at the interosseous membranes during reaming and plaster helped the occurrence of ossification. Fortunately, no dysfunction happened. This reminds us that both forearm fracture at same level may has high risk of ossification of interosseous membranes if treated by intramedullary nails.

Intramedullary nail do have some disadvantages in treating forearm fracture. Extensor pollicis longus rupture is one of the major complications of radius nail[11]. Once not fully protected, rupture of extensor pollicis longus tendon could happen during the using of awl to make entry hole for radius nail. It could also happen when the distal of radius nail protrude dorsal cortex of radius. Another disadvantage of forearm nail treatment is postoperative immobilization. Radial bowing could not be anatomically restored by radius nail too. Too much malreduction of radial bowing may result in nonunion[10].

This study has several limitations. First, the sample size was relatively small. Second this is a respective study without control, so we can not draw any conclusion of superiority. Second, quality of fracture reduction was not evaluated on post-operation X-ray. We simply focus on the function outcome of intramedullary nail in the treatment of simple forearm fracture.

Conclusion

This respective study indicated that intramedullary nail fixation achieved excellent result in the treatment of simple forearm fractures in military combatants.

Declarations

- Ethics approval and consent to participate: The research got approved by Ethics Committee of Army General Hospital (LZEC2019-YW-0126)
- Consent for publication: Informed consent was provided by all participants
- Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
- Competing interests: The authors declare that they have no competing interests
- Funding: NO funding support from any person or organation
- Authors' contributions:

1. Hao Wang . Huayong Zheng: design of the work; the acquisition and analysis,

2. Hongying He . Jianzheng Zhang.Zhi Liu . interpretation of data

3. Tiansheng Sun:drafted the work or substantively revised it

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Figures

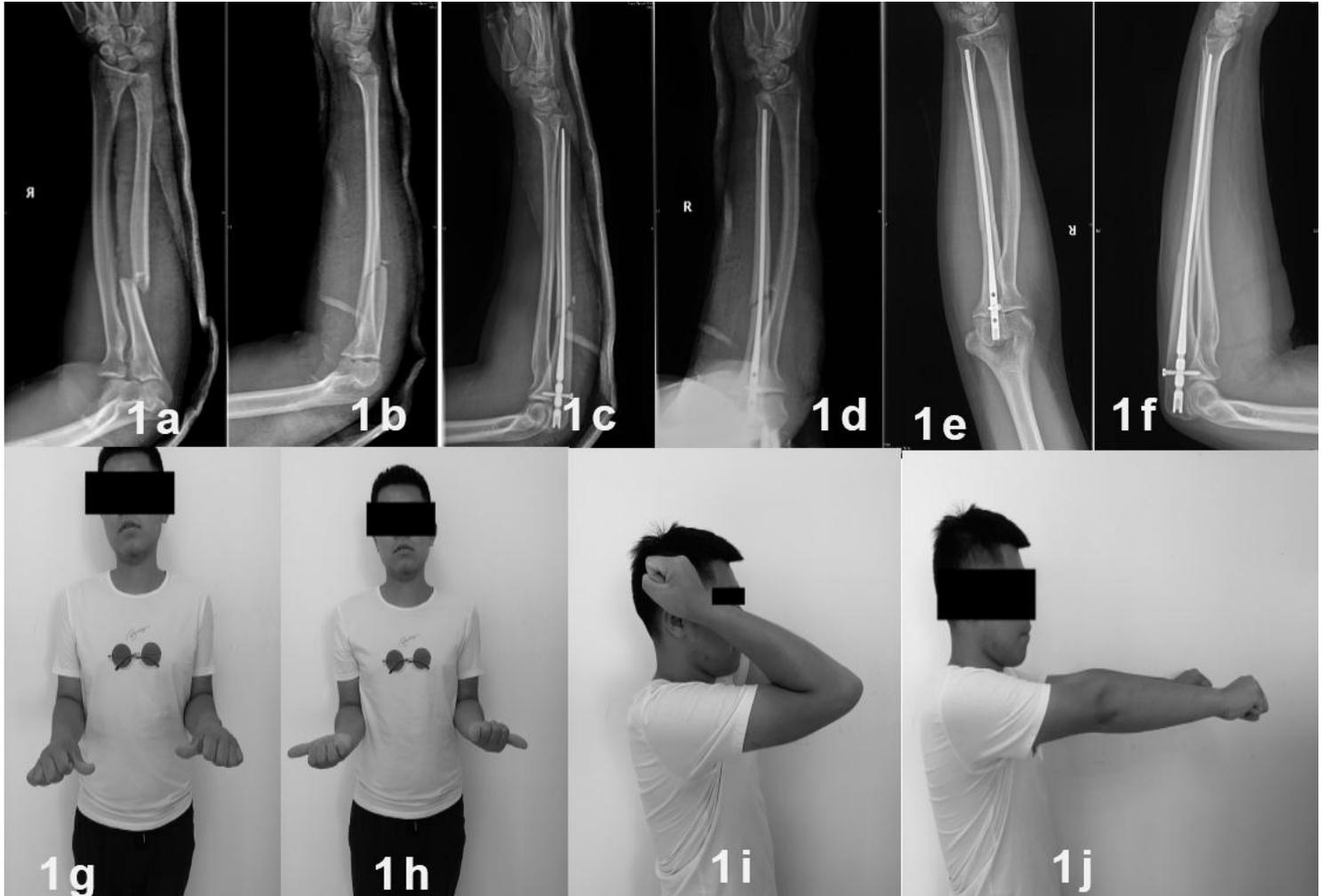


Figure 1

a-b: 19 years old patient,X-ray showed proximal transverse ulna fracture . c-d: Closed reduction and intramedullary nail fixation of ulna with plaster immobilization. e-f: X-ray 12 month post-operation showed successful fracture union. g-i: Flexion-extension and rotation activity was comparable with contralateral side 12 month post-operation.

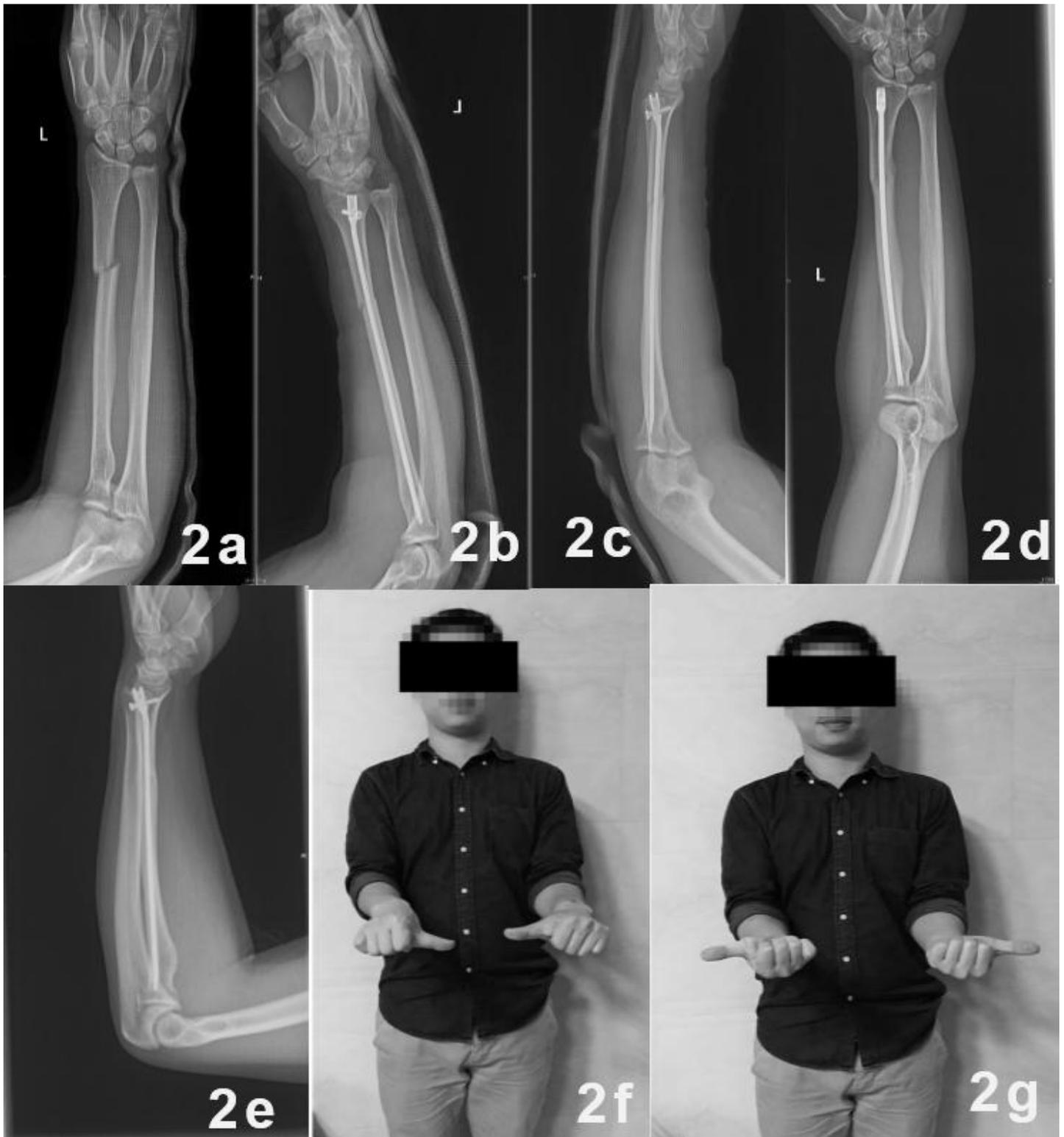


Figure 2

a: 36 years old male patient,X-ray showed short oblique distal radius diaphyseal fracture with mild displacement in left side. b-c: Successful close reduction and intramedullary nail fixation of radius with plaster immobilization. d-e: X-ray 6 month post-operation showed successful fracture union. f-g: Rotation activity was comparable with contralateral side 12 month post-operation.

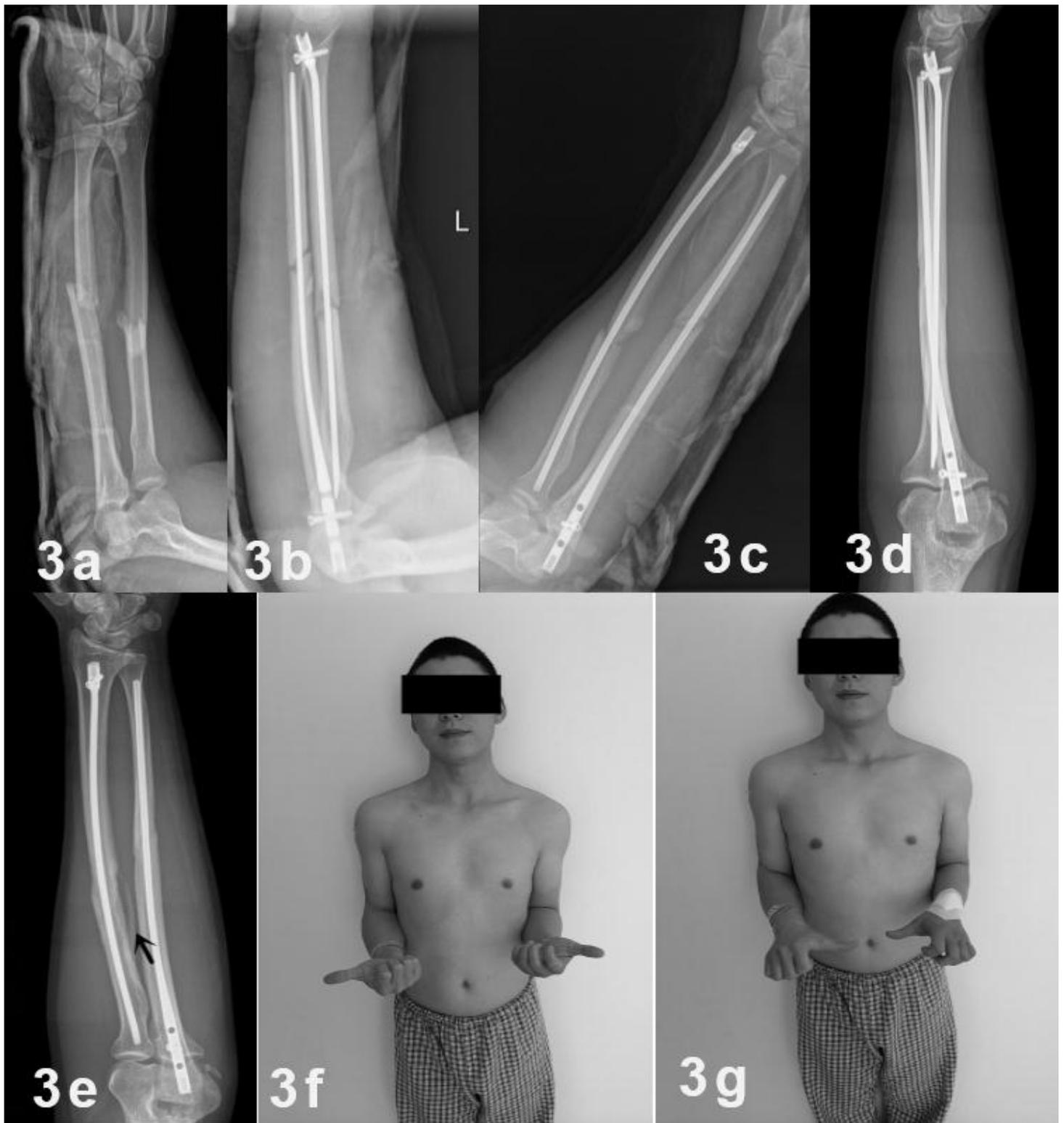


Figure 3

a: 28 years old male patient,X-ray showed short oblique ulna fracture and transverse radius fracture at same level in left forearm. b-c: Successful close reduction and intramedullary nail fixation of both forearm fracture with plaster immobilization. d-e: X-ray 12 month post-operation showed successful fracture union. Black arrow at d showed linear ossification of interosseous membranes. f-g: Rotation activity was comparable with contralateral side 12 month post-operation after the removal of nails.