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Results of using intramedullary autogenous fibular strut graft as an adjunct to dynamic plating in atrophic non-union of humeral mid-shaft fracture

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Abstract
Introduction: Atrophic nonunion of the humerus is rare and complex condition to treat. Several surgical techniques have been used for the treatment of non-union, which include compression plating, intramedullary nailing and use of external fixators, with or without bone grafts. Use of autogenous fibular as a strut graft is proposed to achieve good union and functional recovery. The aim of this study was to assess the clinical result of the intramedullary fibular graft adjunct to dynamic plate fixation in diaphyseal atrophic non-union of the humerus.
Methods: The present prospective study was carried out within the period of January 2019 to December 2021 in the Department of Orthopedic Surgery of Bangabandhu Sheikh Mujib Medical University. Fifteen patient (09 male and 06 female) with atrophic non-union of the humerus midshaft fracture within the age range of 41-60 years were selected. All the case had non-union of the fracture of the middle third of humerus with a delay in commencement of specific treatment. The clinical and radiological outcome of Surgery has been assessed using definite recommendation. Statistical results were obtained by using the SPSS program.
Result: The mean union time was 5.65 months. Post-operative complications were noticed in 3 patients, infection in 01 patient and 02 patients had persistent pain due to failure of union. Regarding the final outcome, satisfactory results were found in 86.66% case and unsatisfactory result in 13.33% case.
Conclusion: The intramedullary fibular auto graft with dynamic plating results in satisfactory clinical outcome in atrophic osteoporotic diaphyseal non-unions of the humerus.

Keywords: Atrophic non-union, humerus, Autogenous fibular strut graft

Introduction
Humerus fractures account for approximately 5-8% of all fractures [1]. Non-union is a rare complication of diaphyseal fractures, reportedly ranging from 1 to 10% in literatures [2]. Several surgical techniques have been used for the treatment of non-union with the principals being open education, freshening of edges and stabilization using compression plates, intramedullary nails and external fixators, with or without bone graft [3]. However, atrophic non-union of the humerus has difficult reconstructive problem because of possible bone lass (shortening) during surgery and osteopenia. A number methods for managing the bony defects have been suggested, among which autogenous cancellous graft (Nicoll) [4], Modified Nicoll fraft [5], cortical strut graft (CSG) [6], vascularized CSG [7], Illizarow [8], bone transport and free vascularized cortico-periosteal bone flap [9] are mentioned but all of them has its own complexities. The first there techniques are relatively simple but the remaining four are complex and needs specialized equipment and centers to manage [10].
Nicoll (or Modified Nicoll) grafting and CSG are supplemented by a plate and screws to stabilize the fracture fragments and bridge the bony defect but > 2.5 cm defect cannot be corrected by the earlier technique, [11] that left the CSG to be the method of choice for adequate treatment. Intramedullary fibula was used to attain the proper length and increase the bone available for purchase of the screw thread. Adequate purchase reduces the chance of implant failure even in the cases associated with osteoporosis [12]. It is common factor for nonunion and is a challenge to achieve adequate osteosynthesis.

The goals for achieving good clinical result in these cases are always a challenge. We have performed this study to assess the clinical result of intramedullary fibular strut graft used with dynamic plate fixation in diaphyseal atrophic non-union of the humerus.

Methods and Materials: This prospective study was carried out from January 2019 to 2021. Fifteen patient within the age range of 41-60 years (male 09, female 06) with Mid-diaphyseal non-united (atrophic) humerus fracture were treated by dynamic compression plate (DCP) fixation with intramedullary fibular strut auto graft further augmented by autogenous cancellous bone graft taken from ipsilateral iliac crest. The cases were selected for the study when there were atrophic diaphyseal non-union of the Shaft of humerus. Patients with an excessively scarred, indurated soft- tissue envelop with a poor blood supply or with infected non-union were excluded from the study. All the cases were assessed preoperative and postoperatively (at 3 month, and yearly thereafter) by X-ray of the shaft of the humerus with proximal and distal joint. We went for radiological diagnosis of Osteoporosis (e.gm marked thinning out of cortical bone and widening of medulla). Because of the rarity and complexity of this specific problem it was not possible to include a control group. Patients were selected when other methods of treatment had been failed or unsuitable to apply.

We followed the Hsu [13] recommendations for radiological union and clinical outcome results. Normal union was defined as the appearance of bridging callus (or bridging of the cortex) and partial obliteration of the fracture within 5 months. Delayed union was defined as union evident in 6-8 months and non-union as no evidence of union within 8 months. Mal-union was defined as varus or valgus deformity ≥ 15 degrees, anterior or posterior angulation ≥ 15 degrees, or shortening ≥ 15 mm, compared with the contralateral side. The follow-up period was an average of 20 months (range, 12-28 months). If the active ROM of the elbow and shoulder were reduced and patients were unable to return to their pre-injury work or activity after operation or patients had unrecoverable neural injury the functional results were deemed unsatisfactory; otherwise, functionality was considered satisfactory. The statistical analysis was done using SPSS program with $p > 0.05$ considered as significant by chi-squared test and t test was done where application.

All patient underwent surgery under general anaesthesia after administration of prophylactic antibiotic. Mid-shaft fracture were exposed thought an anterolateral approach with care taken to protect the Musculo-cutaneous and radial nerves. Fracture fragment were freshened off the devitalized bone and fibrous tissue up the point of bleeding bone ends, and the medullary canal was opened using a drill-bit to reach the fairly healthy cortical bone.

The Mid-shaft of fibula was then harvested under tourniquet control with care taken to identity and protect the superficial personal nerve. Three sides of the fibular graft was trimmed to enable it to snugly fit into the fracture fragment across the fracture site. The strut graft was pushed into one of the fracture fragment and once the final shaping of the graft was done, the fracture was reduced with the intramedullary fibular graft spanning the fracture site. Osteosynthesis across the fracture site was achieved using a dynamic compression plate and screws in compression mode. At least three screws on each side of the fracture with three or four cortical purchase for each of the screws were attempted. After plate fixation, the autogenous cancellous bone graft was harvested from the ipsilateral iliac crest and put carefully around the fractured site. The wound was closed I layers with a drain kept in site.

The arm was immobilized in a sling for 3 weeks. Shoulder and elbow exercises were stared 4 days post-operatively. Aggressive mobilization was initiated after three weeks. Lifting of weights using the operated limb was deferred for a period of three month or until Osseo integration of the fibular ends of fracture healing.

At final follow-up, the patient were examined by an independent observer both clinically and radiologically. Symptoms of pain, instability, or dysfunction were recorded, and the movement of adjacent joints were measured. Complications during surgery and post-operative periods were documented. Radiographs of the humerus in two orthogonal planes were examined for the presence of bridging bony trabeculae indicating union, as well as for evidence of loosening or breakage of the implants. Fracture were considered united if at least three of the cortices on radiographs showed evidence of bony trabecular crossing on the fracture site.

Results

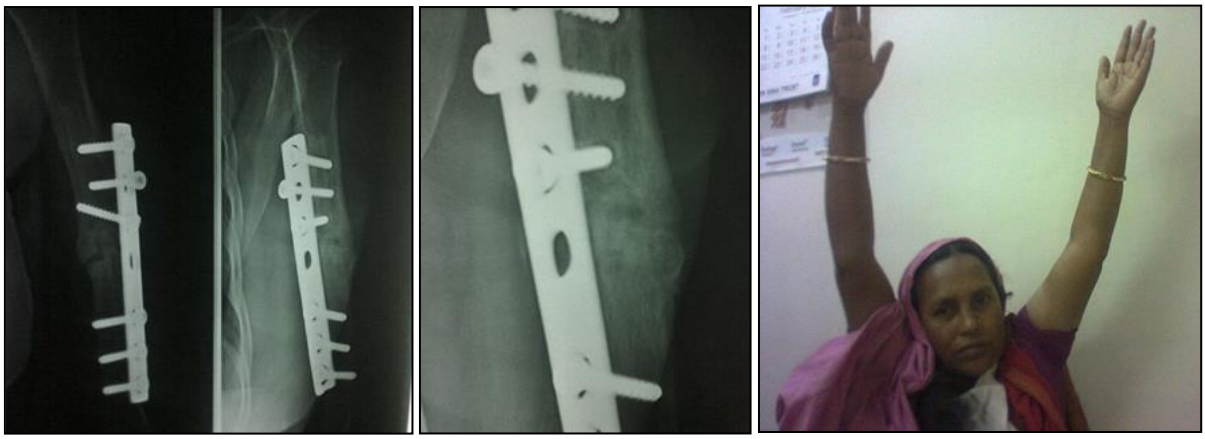
Total fifteen patients were included in this study (male 09, female 06). The ages of the patient ranged from 41-60 years (mean, 49 years) and maximum cases were between 41-50 years age group. All the patient had mid-shaft humerus with atrophic nonunion. All patients had History of trauma, mostly RTA (n=10, 66.67%). Eleven (72.33%) patients were initially managed conservatively and 04(27.67%) were treated surgically. Eleven (72.33%) patients had associated stiffness of the elbow and the remainder had deformity (Table 1). Strikingly 12(80.00%) cases had delay in the commencement of operative treatment even after the diagnosis of atrophic non-union has made. None of the above mentioned demographic variables (age, sex, cause, initial management, associate problem delay of specific treatment) had statistical significance ($p > 0.05$, chi-squared test).

Table 1: Demographic date, (n=15)

Traits		No.	Percentage	Traits		No	Percentage
Age	41-50	10	66.67%	Cause	RTA	10	66.67%
	51-60	05	33.33%		Fall	05	33.33%
Sex	Male	09	60.00%	Associate problem	Stiffness	11	72.33%
	Female	06	40.00%		Deformity	04	27.67%
Initial management	Conservative	11	72.33%	Delay After diagnosis	0-6 month	00	00.00%
					7-12 month	07	46.67%
	Operative	04	27.67%		13-18 month	08	53.33%

In this study, thirteen out of fifteen fractures were healed within six month (Figure 1A, B). Among the two failure cases, one was an elderly obese male with history of smoking and another case had uncontrolled Diabetes mellitus. In 13 patients whose fractures were healed had an average range of active shoulder abduction of 115^0 (Figure 1C) and an arc of

rotation greater than 45^0. At follow up mean of 13.3 month (8-19) four patients had no pain, three had mild occasional pain. Two failed cases had persistent pain.



A. B. C.

Fig 1: Radiological features of healing (A, B) is seen in Post-operative Plain X-Ray of humeral mid-shaft non-union treated with DCP and fibular strut graft with good functional outcome (C)

According to Hsu [13] recommendations satisfactory results were found in 13(86.66%) cases and unsatisfactory result in 13.33% case. These 13 patients showed clinical and radiological features of union within 6 months. The surgical and postoperative complications were minimum in our cases. Only 01 (6.67%) case developed transient radial nerve paresis and there was no incidence of common peroneal nerve involvement during fibular graft harvesting. One (06 .67%) developed superficial wound infection and 02 (13.33%) case had failed to show sign of union at the fracture site. There were no cases with malunion and implant failure as well (Table 2).

Table 2: Clinical result, (n=15)

Clinical result			
Satisfactory	13(86.67%)	Unsatisfactory	02(13.33%)
Complication			
Traits	No. (%)	Traits	No. (%)
Radial near injury	01(06.67%)	Mal-union	00(00.00%)
Wound infection	01(06.67%)	Non-union	02(13.33%)
Common peroneal Nerve injury	00(00.00%)	Implant Failure	00(00.00%)

Discussion

Humeral non-unions can be severely disabling [14] and treatment differs from that of acute fracture [10]. It requires intra focal debridement of bone and fibrous tissue to achieve a well-vascularized bone bed and to allow placement of a bone graft in the nonunion site [15]. When substantial cortex to cortex stability cannot be achieved, supplemental fixation is essential. Deficient plate techniques are one of the main reasons for failure to heal [10] and intramedullary grafting as a major supplement is recommended [16]. The fibula has been widely used to reconstruct humeral defects because of the structural characteristics of the bone (i.e., straight critical bone with triangular cross – section that resists angular and rotational stress) and low donor site morbidity [7]. It provides immediate structural continuity and stability at the fracture site. In addition to acting like a strut, it also has some osteogenic potential. [16] Healy [17] concluded that plate fixation is the most reliable treatment for humeral non-unions. Wright [12] reported eight of nine humeral non-unions healed after treatment with a non- vascularized intramedullary fibular graft with additional plating. We also achieved a satisfactory result by using autogenous fibular strut graft in the cases or mid-shaft humeral atrophic non-unions.

Intramedullary fibula was used to increase the bone available for purchase of the screw thread especially in osteoporotic bones [3, 12]. Biomechanical test have shown the efficacy of using an intramedullary bone graft to improve screw fixation [12] Healy [15] supplemented that the main factor for success was a stable plate fixation achieved by securing fixation of at least six cortices proximal and distal to the nonunion site. It also helps in fixation and provide stability to the fracture site by acting as am intramedullary strut and improves the biological factors as a bone graft. Placing the fibular graft intramedullary facilitated union because of large cortical area between the cortical struts and the end steal surface of humeral. The time required to achieve healing was six months that was comparable to study conducted by Ring *et al.* [14]. None of the patients with healed fractures complains of persistent pain or instability at the site of nonunion and also showed a good range of forward elevation and external rotation of the shoulder within 20^0 of the opposite side. Ring *et al.* [14] showed the similar outcome in their study. Four of his patients hove restricted shoulder movement with forward elevation measuring 60^0, 80^0 and 120^0 and external rotation 20^0, $30^0$and 40^0 respectively. We have achieved satisfactory result in 86.67% case which is also comparable to results of other studies. Vidyadhara [16] also used the similar technique and achieved satisfactory outcome.

A possible disadvantage of this technique is the disruption of the periosteal and the endosteal blood supply [16]. In addition, there is a substantial risk of infection, delayed union, nonunion and fracture through the graft. Although it is believed that skeletal reconstruction with bone grafts frequently fails because the surrounding soft tissue cannot provide adequate vascularity for graft incorporation and even if successful only result in slow revascularization of the dead graft by creeping substitution. However, we did not find any graft desorption or failure in our cases. Although we did not ream the medullary canal but opened it only enough to allow insertion of the fibular graft. We failed to achieve union in 02 cases. Although we did not have any mal-union, graft fracture of implant failure in comparison to other studies [14, 16]. In this series the incidence of superficial infection was 06.67% which is comparable to the result of Hus *et al.* [13]. (02.90%). We did not observe any case with Implant failure

as that of study of Vidyadharan [12]. However, two patient developed superficial wound infection in their study and managed operatively by delayed suture removal and oral antibiotics. In our study, one case with such complication were managed conservatively by regular dressing and IV antibiotics according to the culture and sensitivity report.

The additional disadvantages of using a DCP are stripping of soft tissue and an increased incidence of iatrogenic redial-nerve plasy [17, 18]. The incidence of radial-nerve palsy was 06.67% in this study, which is also comparable to study done by Hsu *et al.* [13] (03.80%) To avoid such soft-tissue injuries, it is important to handle the soft tissue meticulously during surgery. We did not explore the radial nerve routinely, since this seemed to be of no benefit [19]. The management if postoperative radial nerve palsy arising from treatment of humeral shaft fracture remain controversial. Pollock *et al.* [20] suggested that, conservative management with careful observation for sign of improvement of nerve function. Nerve exploration should only be considered within 3.5-4 month after injury if there is no improvement [20]. In our series, the only case with radial-nerve injury was managed conservatively instead of early exploration and it recovered completely within 6 month. The fibular graft harvest has also been reported to have a high potential for peroneal nerve palsy, [16] but if adequate care is taken to identify and protect the nerve during exposure, this complication can well be prevented. Although we had not experienced such incidence, Vidyadharan [16] had 01 patient with transited common peroneal nerve palsy which recovered spontaneously at six-week follow-up.

With our limited resources and present socio-economic condition we had to consider omitting essential diagnostic tools to assess the pre and postoperative osteoporosis by BMD and radiological union by CT scan. As this condition is relatively rare and complex, we were unable to include a large study population with longer follow up.

Conclusion

The intramedullary fibular auto graft enhancing dynamic plate fixation by quadri-cortical screw purchase in atrophic osteoporotic diaphyseal non-unions of the humerus result in satisfactory clinical outcome.

Reference

1. CH Epps Jr, RE Grant. Fracture of the shaft of the humerus (3rd Ed). Rockwood and Green's fracture in adults. J.B Lippincott Co, Philadelphia. 1991;1:843-869.
2. Taylor JC. Delayed union and nonunion of fracture. Campbell's operative Orthopaedics. Mosby year Book, St Louis. 1992;2:1329-1332.
3. EJ Hoglund. A new method of applying autogenous intra-medullary bone transplants and of making autogenous bone screws. Surg Gynecol. 1971;24:243-246.
4. Nicoll EA. The treatment of gaps in long bone by cancellous insert graft. J Bone Joint Surg [Br]. 1956 Feb;38-B(1):70-82.
5. Davey PA. Simonis RB. Modification of the Nicoll bone-graft technique for nonunion of the radius and/or ulna. J Bone Sing Surg. 2002 Jan;84-B(1):30-33.
6. Enneking WF, Eady JL, Burchardt H. Autogenous cortical bone graft in the reconstruction of segmental skeletal defects. J Bone Surg [Am]. 1980 Oct;62-A(7):1039-58.
7. Gerwin M, Weiland AJ. Vascularized bone graft to the upper extremity: indication and technique. Hand Clin. 1992 Aug 1;8(3):509-23.
8. Ilizarow GA. Transosseous Osteosynthesis: theoretical and clinical aspects of the regeneration and growth of tissue New York, etc. Springer-Verlag; c1998. p. 192-96.
9. Andrzej K Heinz B, Ernst JM. Free vascularized cortico-periosteal bone flaps in the treatment of non-union of long bones. Acta Ortho. Belg. 2008 Apr 1;74(2):235-39.
10. Ring D, Jupitar JB, Quintero J, Sandres RA Marti RK. Atrophic ununited diaphyseal fracture of the humerus with a bone defect: Treatment by wave-plate Osteosynthesis. J Bone Joint Surg Br. 2000;8:867-71.
11. Shelton WR, Sage FP Memphic, Tennesse TM. Modified Nicoll-graft treatment of Gap Non-Unions in the upper Extremity. J Bone Joint Surg. 1981 Feb 1;63A(2):226-231.
12. Wright TW, Miller GJ, Vander Griend RA, Wheeler D, Dell PC. Reconstruction of the humerus with an intramedullary fibular graft. A clinical and biomechanical study, J Bone Joint Surg. 1993 Sep;75-B(5)804-807.
13. Hsu TL, Chiu FY, Chen CM, Chen TH. Treatment of nonunion of humeral shaft fracture with dynamic compression plate and cancellous bone graft. J Chin Med Assoc. 2005 Feb;68(2):73-6.
14. Ring D, Perey BH, Jupitar JB, The functional outcome of operation treatment of ununited fracture of the humeral diaphysis in older patients. J Bone Joint Surg Am. 1999 Feb 1;81(2):977-83.
15. Jupiter JB, Von Deck M. Ununited humeral diaphysis. J Shoulder Elbow Surg. 1998;7:644-53.
16. Vidyadhara S, Vamsi K, Rao SK, James J. Use of intramedullary fibular strut graft: a novel adjunct to plating in the treatment of osteoporotic humeral shaft nonunion International Orthopaedics. 2009 Aug;33(4):1009-1014.
17. Helay WL, White GM, Mick CA, Brooker AF Jr, Weiland AJ. Non-union of the humeral shaft. Clin Orthop. 1987;219:206-13.
18. Patel VR Menon DK, Pool RD, Semonis RB, Nonunion of the humerus after failure of surgical treatment. Management using Ilizarov circular fixation. J Bone Joint Surg Br. 2000 Sep;82(7):977-983.
19. Hornicek FJ, Zych GA, Huston JJ, Malinin TI. Salvage of humeral nonunion with only bone plate allograft augmentation. Clin Orthop. 2001;363:203-9.
20. Pollock FH, Drake D, Bovil EG, Day L, Trafton PG. Treatment of radial neuropathy associate with fracture of the humerus. J Bone Joint Surg Am. 1981;63:239-43.