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Evaluation of Three Bridging Tricorticocancellous Bone Grafts in the Treatment of Old Non-uniting Fractured Humerus

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Abstract

BACKGROUND: Non-union of humeral shaft fracture after conservative treatments or frequent failed surgical treatment of bone healing exemplify the difficulties in managing a bone defect or severely damaged individuals.

AIM OF THE STUDY: This is a cross-sectional study, to evaluate three bridging tricorticocancellous bone grafts in the treatment of old non-uniting fractured humerus.

MATERIALS AND METHODS: From June 2014 to December 2019, three bridging tricorticocancellous bone grafts were used to treat non-union humeral shaft fractures using dynamic compression plates at Sulaimani Teaching Hospital in Iraq.

RESULTS: Sixteen patients, 11 males, and five females, varying in age from 28 to 64 years old (mean age 41) were recruited for the study. Six patients had previously undergone conservative treatment, and 10 patients had previously undergone surgical treatment, such as open reduction and internal fixation with plates and screws or various intramedullary nails. Four out of 10 patients had previously received bone transplants in conjunction with internal fixation. The non-union lasted between 2 and 4 years (a mean of 3 years). In patients who were treated by recanalization of the medullary canal, healing rate of a non-uniting fractured shaft humerus reached 100% in all 16 patients, indicating improvements in both bone healing and functional index outcomes. The percentage of scoring for satisfaction rate was in 15 patients (93.75%) out of 16 (100%). Furthermore, the function score was excellent in 15 patients (93.75%) out of 16 (100%), while the movement score was in 14 patients (87.5%). The union rate, angular deformity, and limb shortening were used to evaluate bone results.

CONCLUSION: When using of medullary recanalization technique opening the bone canal, and fixation by dynamic compression plate for old non-uniting fractured shaft humerus patients, the findings confirm that three bridging tricorticocancellous bone grafts are superior in healing and union, improved arm function, and a high satisfaction rate as achieved.

Introduction

Humeral shaft fractures contribute to 3% of all bone fractures in the body, as well as 20% of all humeral bone fractures. Accidental traumatic falls, road traffic accident (RTA), or other severe traumatic injuries are all possible causes. A non-union is diagnosed based on clinical signs of non-healing, such as movement at the fracture site and a loss of upper-limb functions. Finding in X-rays reveals a lack of bone across the site, with the fracture line still visible, indicating non-union. Conservative treatment with a cast stabilization, plastic splint results in a high-rate union of humeral shaft fractures in over 90% of cases. Furthermore, a major factor of non-union in the local environment is that many patients seek traditional bone setters, which results in delayed and nonunion fractures in general [1], [2], [3].

About 60% of humeral fractures occur in the middle third of the shaft, 30% in the proximal third, and 10% in the distal third Tytherleigh and colleagues [4]. Gender and age are causal agents, with major trauma occurring more frequently in men as traumatic factors. However, the majority of patients are elderly osteoporotic women over the age of 70 related to minor trauma. Development of particularly atrophic nonunion is an inadequate angiogenesis caused by the initial trauma or subsequent to surgical interventions [5].

In patients managed conservatively, 8% of nonunion accounts were reported. However, after surgical open reduction and internal fixation with plating screws or closed IM nailing, there was a 13% non-healing percentage. exchange to a bigger sized nail plus reaming debris produces a rich number of osteoblast-like cells, growth factors and viable osteoprogenitor cells, insufficient reduction, and fixation of the fracture, risk of irregular healing process is increased significantly, further more atrophic non-union revealed a lack of osteogenic cells and growth factors in fracture site were detected less vascularity at the defect gap [6], [7].

Hypertrophic, atrophic, gap, and oligotrophic non-unions, as well as pseudoarthrosis, are the different types of non-uniting shaft humeral fractures. Insufficient

blood reaching the fracture site is the most common factor that leads to atrophic nonunion [8]. Patient-related factors have multifactorial causes, such as advanced age, poor nutrition, steroid therapy, obesity, diabetes mellitus, and shoulder motion limitation. Open injuries, transverse fractures, bone loss resulting in a gap, soft tissue interposition, stripping injuries to muscle and periosteum, compromised blood supply following injury to a nutrient artery, as well as severe comminution, also obesity, diabetes mellitus, and restriction in shoulder movement are all injury-related factors of multifactorial causes [9].

The orthopedic surgeons face a difficult task in the treatment of humeral shaft non-union. Absence of bony union in the humeral shaft after 6 months of treatment is known as nonunion [10], [11]. Non-union can now be treated with internal plate fixation, and adjuncts such as allograft, autograft, platelet-rich plasma, stem cells, bone morphogenetic proteins, and demineralized bone matrix [12].

The risk of complications and additional surgical procedures must be balanced against the treatment goals of humeral shaft non-union repair, which include good post-operative functional outcomes, a faster rate of healing, and a shorter recovery time [13]. Although it has been proven that adding a bone graft improves healing rates, the best bone graft type is still unknown. The availability of growth factors and osteogenic cells, within osteoconductive scaffold, mechanical fixation plus efficient vascular supply is important fact in fracture healing [14], [15].

Materials and Methods

The aim of the present study the goal of surgery is stabilize rigid fixation on healed nonunion fracture humerus, plus early mobilization was achieved by medullary canal recanalization, plus layers preparation of bone graft, designed and settled by the author Dr. Ahmed Alkhuzai Orthopedic Surgeon, University of Sulaimani, College of Medicine, Orthopaedic Department.

Ethical approval and study group

This is a cross-sectional study. Ethical approval was obtained number 42 on date of March 16, 2022 from the Department of Orthopaedic Surgery Research Registration Form number 190 on date of February 21, 2022, College of Medicine, Sulaimani University, Iraq. From June 2014 to December 2019, a total of 16 patients were randomly gathered from private clinic patients with old non-uniting fracture humerus at a private hospital.

A closed medullary canal was reopened for the non-union segment of the fractures using a special type of drilling bite to return to the original diameter of the bone medullary canal. The bridging of tricorticocancellous bone graft was in three layers, using the filling gap of non-union fracture or pseudo joint nonunion in fractures. All of the patients were treated with this method, which included the use of a compression plate to fix the nonunion bone. Patients with more than 2 years of nonunion and functional difficulties in arm movements were diagnosed with old non-uniting humeral shaft fractures. These patients had previously been treated conservatively or surgically with an intramedullary nail or cortical fixation. If a long bone fracture fails to unite after 6 months, there is an obvious radiological finding of absence of bridging callus on the film, and/or complete arm mobility into two segments with the instability of the non-union fractured shaft humerus, and a functional defect during upper-limb movements. The study excluded patients with actively infected non-unions.

The present cross-sectional study is being conducted on patients with non-uniting fractures. The sample for this study was collected following the World Medical Association's Code of Ethics (Declaration of Helsinki) for human subjects' experiments. A research protocol approved by Sulaimani University's School of Medicine Ethical Committee was used. Before the study began, each subject provided written informed consent. SPSS version 25.0 (Armonk, NY: IBM Corp, USA) for Windows was used to analyze numerical data. The categorical data were influenced by the number of patients included in the study.

This method was used to treat patients with non-uniting humerus fractures. From June 2014 to December 2019, non-union humeral shaft fractures were evaluated with medullary canal recanalization, plus fixation by dynamic compression plate at Sulaimani Teaching Hospital, Iraq. Sixteen patients collected randomly, presented with nonunion humeral shaft fractures who had been treated conservatively or surgically, were previously treated accordingly: Six patients treated conservatively, 10 patients were primarily treated surgically with cortical plating or intramedullary fixation, and four patients out of 10 had previously used autologous bone graft. There were 11 right-sided non-union and five left-sided non-union humeral patients out of a total of number 16. The non-union lasts between 2 and 4 years, with the average time spent in non-union being 3 years for all patients. The mean age was 46 years (range 28–64 years) with a male-to-female ratio of 12 (75%)–4 (25%). Seven patients (43.75%) had open trauma, while 9 patients (56.25%) had closed fractures, as shown in Table 1.

A non-union is a fracture that has not healed after 6 months or more, as evidenced by the lack of a bridging callus on X-rays and/or movement of the fracture site with a functional defect in upper-limb movements during daily life activities.

Table 1: Patient's characteristics

Patients characteristic	Numbers	Percentage
No of patients	16	100
Conservative treatment	6	37.5
Surgically treatment	10	62.5
Bone graft once time	4 out of 10	40
Right side only	11	68.75
Left side only	5	31.25
Open Fractures	7/out of 16	43.75
Closed fractures	9/out of 16	56.25
Mean of age	28–64 years	
(Minimal-Maximal)	46 years	
Female to male ratio	12M/4F (Out/16)	M: 75–F: 25%
Body weight	(86–82)	-
Mean (Maximal-Minimal)	84 kg	
Body height	(166–162)	-
Mean (Maximal-Minimal)	164 cm	
Duration of nonunion	2–4 years (average 3 year)	-
Mean times for healing (union)	4.3 months	-

Exclusion criteria

Patients with actively infected non-unions were not included in the study, as well as other associated injuries or body trauma, were also excluded from participating in the study. All patients with old non-uniting humeral fractures that have been non-union for more than 2–4 years were excluded from the study, also excluded patients with nerve or vascular injury from this study.

Inclusion criteria

All patients who have been treated with conservative or surgical modalities (internal fixation by cortical plate, intramedullary nail, or external fixation) were included in the study, all patients with closed or open trauma were included in this study.

Operative treatment techniques

Prophylactic antibiotics were given to all 16 patients. For non-union shaft humeral fracture, the anterolateral technique was employed, relying on the lateral edge of the biceps muscle. Then, dissection was carried down deep to the brachialis splitting until the non-union site was reached. The nonunion site plus movement were detected, non-union segment of humerus was evaluated proximally and distally, with all fibrous connective tissue removed. The use of autogenous bone graft from iliac bone in three layers as bridging material between the proximal and distal segments of a non-union fracture is the principle of bone graft. Bone grafting to augment bone healing was separated into three layers, as shown in Figure 1.

The first layer was an endosteal medullary canal bridging graft across the proximal and distal segments of the non-uniting broken humerus, made largely of autogenous iliac crest bone grafts (ICBG) taken from the same patient's autogenous iliac bone graft. The second layer is made up of autogenous cortical bone from the same patient, as well as some cancellous bone transplants in the cortical site of non-union. The periosteal outlay cortical graft layer of autogenously

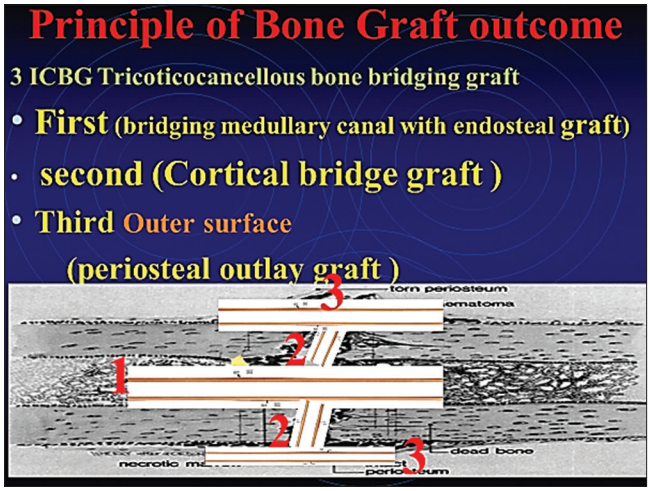

Figure 1: Principle of three-layer graft of bone

generated iliac graft is covered by the third layer of outer cortical surface. To approach the non-union site, for patients treated for non-union fractures by surgical exploration in cases of the previous surgical treatments, the existing operative scar was used. Except for patients treated previously by conservative means, an approach by anterolateral exploration was used. Figures 2 and 3 show the radiological images of patients that were previously been treated with conservative or surgical fixation with union failure.

The non-union location was debrided by removing all remaining fibrous tissues, refreshing sclerotic edges to create a bleeding surface, and then opening the intramedullary chambers of the proximal and distal fragments. The pseudo joint that is the major cause of the continued non-uniting fracture shaft humerus was between 6 and 20 cm sclerotic closure of the diameter of the humerus bone in the non-union site, which represents the recanalization and opening of the medullary canal proximal and distal segments. The widening began with a small diameter drilling bite and progressed to a huge drilling bite for recanalization and medullary canal widening of the shaft humerus nonunion site, which is well apparent in Figure 4. The recanalization openings are of the medullary canal proximal and distal segments of the patient's non-union humerus.

All patients were treated with this method, which included using a compression plate to fix and stabilize non-union shaft humeral fractures, irrigating the wound frequently before implanting graft layers in the non-union site, suturing tissues in layers as needed, and dressing with cotton and bandages. Depending on the type of nonunion fracture, external splintage, such as a plastic shell or arm sling, may be necessary. Physiotherapy for both the shoulder and elbow joints, as well as home exercises, began after 1–3 weeks. These patients were gradually allowed to use their shoulder and elbow joints through physical exercise and daily activities until bone healing was achieved and bone bridging was observed on monthly digital

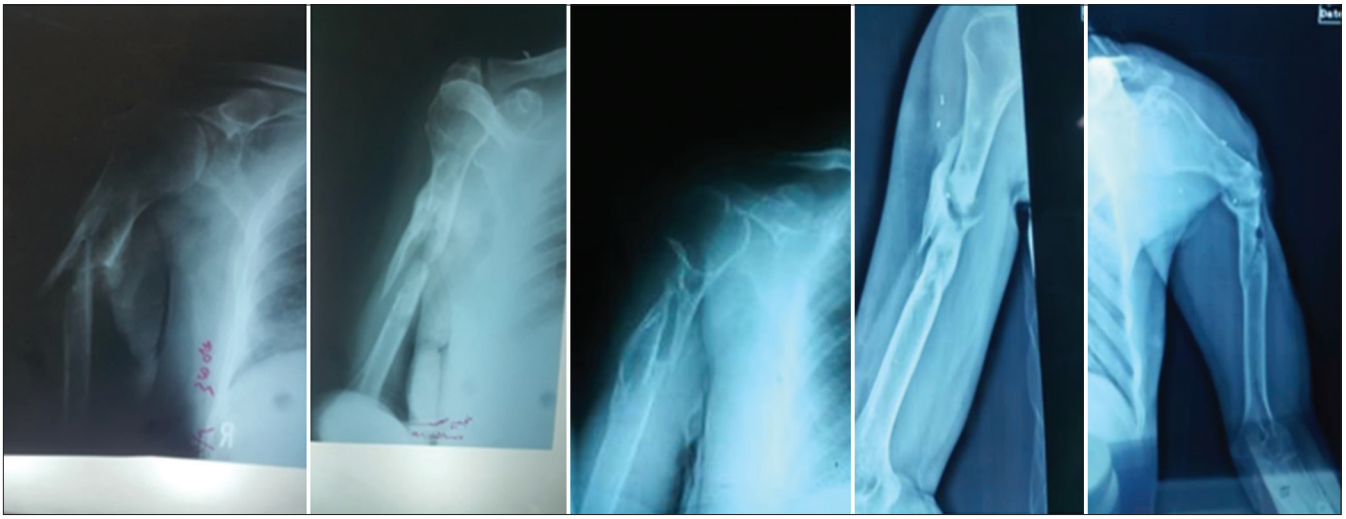

Figure 2: Preoperative nonunion fracture humerus without previous surgical fixation

X-rays. Union rate, angular deformity, limb shortening, and infection rate in deep bone infection or superficial soft-tissue infection were all factors in the outcomes. Estimating the functional results for pain, function, movement, muscular power, and patient satisfaction is also necessary.

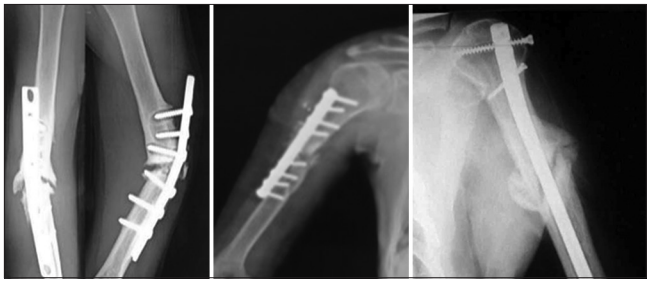

Figure 3: Nonunion fracture of the humerus prior to surgery with various types of fixations (Previous Surgical Treatment-our patient)

Results

Sixteen patients ranging in age from 28 to 64 years old (mean age 46 years) were evaluated. There were 11 men and five women in the group. Four patients suffered from open fractures (two due to missed injuries, the third one due to machine injury, and the last one was as a result of RTAs). Six of the patients had previously received conservative treatment, and previously 10 patients had received surgical treatment in the form of open reduction and internal fixation with plates and screws, or intramedullary nails of various types. In four out of 10 patients, bone grafts had previously been employed at least once in conjunction with internal fixation. Non-union lasted on average 3 years but might reach 4 years. In this study, both the bone healing index and the functional index outcomes improved. The union rate, angular deformity, limb shortening, and infection rate were all used to evaluate the bone results. Pain, function, movement of the shoulder and elbow joints, muscle power, and patient satisfaction were all assessed as functional outcomes. The union rate, angular deformity, limb shortening, and infection rate were used to assess the bone healing index result and functional index outcome. Pain, function, joint movement, muscular power, and patient satisfaction were all assessed as functional outcomes.

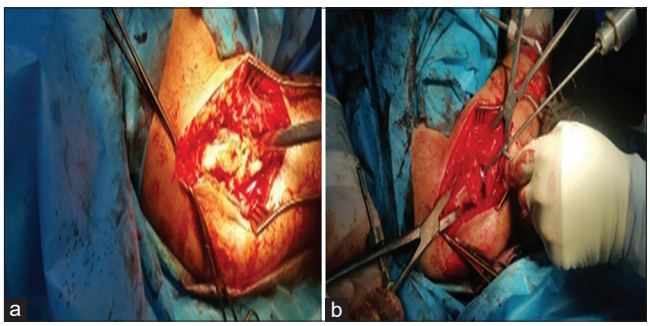

Figure 4: Intra operative procedure of patient with nonunion humeral segmental closure- recanalization opening of proximal and distal segments

The results were evaluated in terms of both bone and functional outcomes. The patient was allowed to conduct active workouts of all joints and utilize his arms in daily activities. Furthermore, X-rays of the non-uniting fractured humeral bone were taken once a month until radiographic evidence of bone healing and bone graft incorporation was found as well as great functional mobility was achieved. With a rigid solid bone union, all 16 patients were healed in an average of 4.6 months. Seven patients (43.75%) had previous open trauma, while 9 patients (56.25%) had closed fractures as a result of the etiological factors. The study mostly excluded 4 instances (20%) that presented with infection. Fixation with various types of internal or external implants, with or without a bone grafting, was part of the earlier surgical procedures. All patients had autogenous ICBG produced and placed in the nonunion location. The bone result evaluation revealed that no failure of healing was observed for those patients who

were treated by recanalization of the medullary canal, and the healing results of non-uniting humeral fractures reached 100%, as shown in Figures 5 and 6.

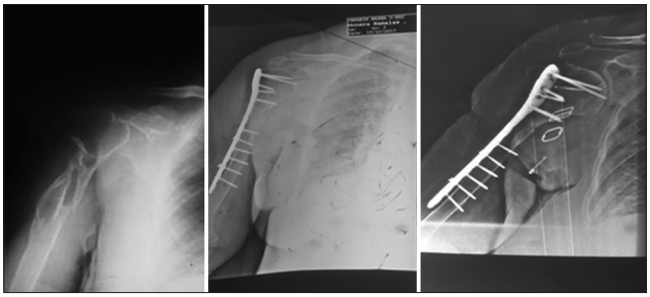

Figure 5: Preoperative-postoperative treatment by fixation and three-layer tricorticocancellous bone graft

The pre-operative and post-operative radiological images were treated with fixation and a three-layer tricorticocancellous iliac bone grafting procedure. In three cases, bone shortening of <3 cm was discovered, accounting for 18.75% of the total. The reason for the shortening was mostly due to prior trauma.

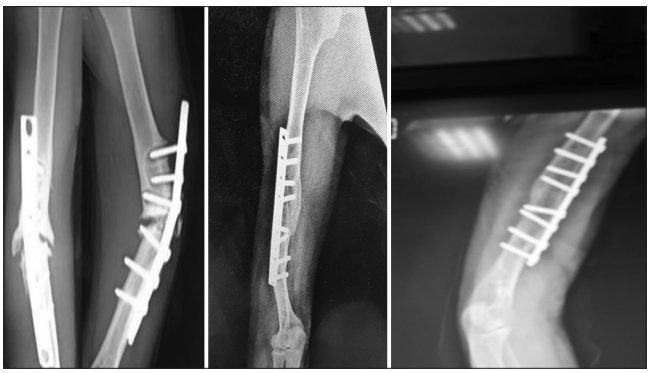

Figure 6: Preoperative-postoperative treatment by fixation and three-layertricorticocancellous bone graft

An angular malformation of no more than 15 degrees was observed in 2 patients (12.5%) out of 16. The movement of joints was unaffected by this angular malformation. The infection affected 3 (18.75%) out of 16 patients, two patients (12.5%) had a superficial soft-tissue infection, and 1 patient (6.25%) had a deep or bone infection, both of which were well controlled by the treatment described in Table 2.

Table 2: Bone results of union rate, angular deformity, limb shortening, and infections

Bone Results	Patients/Number	Percentage
Union rate	16 (Mean Times for Healing 4. 3 months)	100
Angular deformity	2	12.5
Limb shortening	3	18.75
Infections		
Soft tissue	2	12.5
Deep/bone	1	6.25

According to the evaluation of the functional outcome, there was just one patient with mild-to-moderate pain (6.25%) persistence in nature. However, the fractured bone was healed with a good union and no pain persisted throughout normal activities, as expected. Functional scores for daily activities improved in 15 patients (93.75%), and movement of the joints in the shoulder and elbow improved in 14 patients (87.5%). Furthermore, muscle power was good around the shoulder and elbow joints in 13 patients (81.25%), and the satisfaction rate score represented high satisfaction in 15 patients (93.75%). Shoulder and/or elbow joint resulted in very mild-to-moderate stiffness in two patients, as well as some degree of movement limitation, reflecting the delayed presentation for treatment of the non-uniting humeral fracture, as shown in Table 3. There was no case of iatrogenic nerve or vascular injury before or after the treatment in these patients.

Table: 3 Functional outcomes (pain, function, movement, muscle power, and patient satisfaction)

Functional outcome	Number of patients/16	Percentage
Pain (Persistence of Pain)	1	6.25
Movement Score Excellent (Shoulder& Elbow in all direction)	14	87.5
Muscle Power (Excellent Grade)	13 (Good and Excellent grades)	81.25
Patient Satisfaction	15	93.75
Function Score	15	93.75

Discussion

Non-union of the humeral shaft presents a significant therapeutic challenge, and many patients with these fractures are subjected to repeated operational procedures in an attempt to achieve union. The most popular techniques of therapy for non-union fractured shaft humerus are compression plating with screws or interlocking screws used to secure intramedullary nails, with a focus on a specific type of bone transplant for these fractures. The use of three tricorticocancellous bone bridging grafts, as well as medullary recanalization of non-uniting fractures, was an essential step in improving the healing of non-union humeral fractures. The three layers were evident in the bone graft principle picture. Mild-to-moderate joint stiffness was reported in 2 patients (12.5%). The ability of shoulder rotation, internal, and external, to reach the hand above the head as well as the elbow joint in an appropriate range of movements was demonstrated in 14 patients, with an outstanding rate of 87.5%.

The abduction range was enhanced, and these movement improvements in a stable rigid arm resulted in a high rate of satisfaction of 93.75%. The results showed that the union rate reached 100% with a high rate of acceptance in all 16 patients included in the study. In all 16 patients, no failure percent of healing union was observed after recanalization of the medullary canal employing this principle of bone transplant. However, two patients with angular deformity (12.5%) and three patients with shortening apparent (18.75%) had delayed presentation and treatment, but these problems did not impair the patients' satisfying and functional outcomes. Stiffness with mild-to-moderate limitations of movement in the shoulder or elbow joints accounts for 12.5% of cases, indicating a delay in diagnosis and treatment, with 14 patients (87.5%) of those with great mobility.

Other complications encountered during curing of non-uniting humeral shaft fractures bone included infection (18.75%), superficial infection in soft-tissue visible in 2 patients (12.5%), and deep infection visible in 1 patient (6.25%), all of which were well controlled with antibiotics and movement restriction until healing. Furthermore, the pain persistent in nature was observed in one patient at a rate of 6.25% during the healing process, which was treated with a mild pain reliever and a movable splint until complete union healing. In any of the patients, there was no evidence of iatrogenic nerve or vascular injury preoperatively or postoperatively. Rigid bone healing in 16 patients is (100%) with union humeral shaft fracture, the functional outcome in 15 cases (93.75%) with a functional score, and a good patient outcome in 15 cases (93.75%). The average time for radiological bone healing was 4.5 months (a range of 3–6 months).

The recanalization of the medullary canal, which leads to rapid healing of non-uniting long bone fractures, is the principle of non-uniting humeral fracture healing with a high rate of the union. The healing is improved by transferring osteoprogenitor cells from the recipient to the donor bone transplant. Early mobilization, on the other hand, is important in preventing stiffness in the shoulder and elbow joints, which are major factors in joint mobility surrounding fractured bones. Non-union of the humeral shaft poses significant treatment obstacles. To achieve union, many patients with this fracture are subjected to repeated surgical procedures.

The most frequent techniques for treating non-union fractures include compression plating with screws, as well as bone graft with humerus bone canal employing recanalization and bone graft resulting in a high rate of healing [16]. Non-union is caused by several factors, including advanced age, obesity, poor nutritional status, diabetes mellitus, use of corticosteroids, alcoholism, fractures underlying burns, anticoagulation, previous radiation, and poor patient compliance. Open fractures, transverse fracture patterns, infections, primary open reduction, soft-tissue interposition, poor immobilization, shoulder motion limitation, and distraction of the fracture site are all factors that contribute to delayed or non-union (most often the result of a transverse or short oblique fracture treated with a hanging arm cast) [17]. Bone marrow graft where substitute have been shown beneficial effects on bone healing in plate stabilized for non-union proximal humerus fractures [18].

Non-union variables in the environment indicated bone setter sharing treatment of general trauma and fractured patients, transverse fracture types, primary open technique reduction, soft-tissue interposition, and poor immobilization, according to the results of this study. Infections were not included in the research. The reason for success in this study was the use of the recanalization medullary canal procedure to carry osteoprogenitor cells from the donor site to the recipient site of non-union. Furthermore, rigid fixation by compression plate, which resulted in a high union rate of healing, ensure sufficient debridement of devitalized tissue, and defect filling, similar to Rupp and coworkers' procedure were recommend compression plating in combination with bone grafting. They obtained a persistent humeral shaft non-union with a comparable success rate [19]. The patients who had many previous surgeries and recurrent non-unions in the shaft of their humerus were treated with a lengthy compression plate and a tibia onlay bone transplant with screw fixation applied at 90 degrees to the plate. The cause of healing was primarily the removal and cleaning of sclerosed thick bone within the non-union site.

The widening and recanalization of the humeral shaft canal were another component, and the good distribution of bone graft was the principle in the non-union site. The capacity for union is increased by connecting the distal and proximal segments and internal fixation with a compression plate leading to a high rate of healing union of this long humeral shaft fracture [20]. These principles are in support of the results obtained in this study using a three-layer bone graft and recanalization of the medullary canal of the non-uniting fractured shaft humerus bone.

The results of researchers who treated 4–6 non-unions with an interlocking IM nail reported a 100% union rate, which was identical to the findings in this study using a compression plate for internal fixation. Both techniques use the principle of the incorporated bone graft by widening and recanalization of the bone canal in non-uniting shaft humerus fractures and mechanical stability plus osteogenesis supply high rate of healing non-uniting humerus bone [21].

The rigid fixation plus iliac crest autograft results in a high success rate for non-union shaft humerus. Jupiter. on the other hand, used a vascularized fibular graft to achieve 100% healing and union in four patients [22]. In this study, a lower level of complexity that was explained in both of the above procedures, as well as a good rate of healing of the union shaft humerus bone, with fewer complications were achieved.

In a retrospective study conducted in 2000, 12 patients with nonunion humerus bone fractures were treated with intramedullary fibular allograft and compression plating in a retrospective study. Two out of 12 (16.7%) patients with a high rate of movement failures and comorbidities were observed. When the researchers combined the fibular allograft with compression plating, they were able to achieve a high rate of healing and satisfactory results shown by Padhye KP, and his colleagues were used strut fibular graft in 2013 [23]. However, utilizing a compression plate and a three-layer bone graft in the medullary canal after recanalization, a high rate of healing union of 100% was attained. Richards (2013) examined 35 patients, nine women and 26 men, who had shaft humerus non-union. He compared several therapeutic techniques for

fixation (plating, external fixation, nailing, or fibular strut allograft). He obtained the best results in compression plating. Fibular strut grafting, on the other hand, was found to be beneficial for non-union shaft humerus fractures that were not stable. These contributed to the success recorded in using compression plates in fixing [24].

The fibular allograft is a rigid corticocancellous material, which can prevent compression or bending. Furthermore, it provides stability to non-uniting shaft humerus bone, as well as reduces tension on the fixation plating. A fibular strut graft allows screws to be fixed, resulting in a more stable bone. The absence of osteoplastic and osteogenic cells, as well as the absence of other growth factors in the non-uniting site, could be the true cause of non-healed nonunion humeral shaft fractures. Thus, it is for a reason other than a defect in vascularity following medullary canal closure as a result of decreased vascularity at the defect gap [25], [26].

The high concentration of osteoblast-behaving cells, plus growth factors, and the introduction of osteoprogenitor cells from the recipient into the non-uniting bone of the donor, aided by mesenchymal stem cells from the bone graft, will improve the healing of non-uniting shaft humerus fractures [27]. Both intramedullary and extramedullary applications were used to obtain the improvement. Furthermore, the corticocancellous iliac crest autograft had no significant morbidity at the donor site, with only minor complaints of pain at the donor site subsiding after a few days, and some incidences of infection being documented [28]. Another advantage of these procedures is that they do not require high-tech equipment or microvascular techniques. In the present study, using the autograft bone procedure, the fibular allograft posed no risk of disease transmission or infection, and there was no chance of infection being communicated to the patients. Non-unions treated with intramedullary nailing or humeral shaft fractures treated with compression plating have no significant differences.

In the case of non-union, however, compression plates provide a stable fixation with a high rate of healing and fracture union, particularly when combined with bone graft [29]. Shortening the non-union lead to more compression; bone graft must be added if the defect is more than 3–4 cm long [30].Bone graft type supports both osteogenesis plus the amount in distribution inside non-union defect same as principle of our study [31]. Revision using compression plate plus osteogenesis bone graft achieved high rate of healing non-uniting fractures humerus demonstrated by Lin CL and his colleagues [32]. Bone graft as osteogenic property effect healing of non-uniting fractures humerus plus fixation by compression plate achieved by Hierholzer C, and his colleagues [33].

These observations that discussed above are in agreement with the findings of the present research, in which three layers of cancellous bone graft inside the non-uniting shaft humerus bone were used. Furthermore, three osteoconductive scaffolding procedures were applied, leading to osteointegration and osteoconduction. This application enables the growth factors and osteoprogenitor cells from the recipient to be brought to the donor bone graft. Furthermore, vascular redirection support from medullary recanalization encourages healing and union of these non-uniting shaft humerus bone fractures.

There are some limitations to this study. First, the pre-operative rating was not available for previously treated patients, resulting in a challenging comparison. All of the individuals with a nonunion shaft humerus had a flail extremity and a deficiency in the upper limb movements. Second, the study's sample size was small, which indicates that this sort of fracture heals quickly. However, when compared to other related subjects with the same type of fracture shaft humerus, especially with the same surgeon, the patients in this study were the same.

Conclusions

Although humeral shaft non-unions are uncommon, when they do occur, they can be difficult to treat. The findings in this study reveal a treatment option that has a high rate of success in attaining union, even in patients with real pseudoarthrosis. When using the procedure of medullary recanalization to open the bone canal, and fixation by a dynamic compression plate for old non-uniting fracture shaft humerus patients, the three bridging tricorticocancellous bone grafts are superior in healing and union, improved arm function, and have a high satisfaction rate.

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