

Original Research Article

Our experience with percutaneous autologous bone marrow injection in the management of delayed and nonunion of long bone fractures

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ABSTRACT

Background: Various modalities of treatment are available for the management of delayed and nonunion of long bone fractures. The aim of this study was to evaluate the role of percutaneous autologous bone marrow injection in the management of these fractures and to compare the results with studies of other authors as available in literature.

Methods: 15 patients with delayed and nonunion of long bone fractures were studied between January 2013 to January 2015 and were followed up for a period of 1 year. The patients were clinically and radiologically evaluated at regular time intervals at follow up.

Results: The age of the patients ranged from 28 to 60 years with the mean age being 44.2 years. There was a male preponderance in our study with the male to female ratio being 2:1. The left side was more commonly affected as compared to the right. The mean time to radiological appearance of callus was 6.4 weeks. The mean time to clinical union was 7.33 weeks while the mean time to radiologic union was 13.4 weeks. We had a union rate of 93.3% in our series with one fracture going in for failure of union.

Conclusions: Percutaneous autologous bone marrow injection is a minimally invasive, safe and cost effective option in the management of delayed and nonunion of long bone fractures and gives good functional results.

Keywords: Bone marrow, Injection, Delayed union, Nonunion

INTRODUCTION

Fracture healing is a process in which there is a progressive regeneration of the bone which occurs in stages resulting in restoration of the skeletal integrity. In certain situations, the healing process is either delayed or impaired due to various factors. The various factors implicated in impaired fracture healing have been infection, soft tissue interposition at the fracture site, wide separation of fracture fragments without bony contact, improper fixation, inadequate immobilization and also patient variables such as immunocompromised status, smoking, anemia, chronic steroid use, cachexia and metabolic bone disease.¹⁻³ Various modalities of treatment are available for the management of delayed

and nonunion of long bone fractures such as low intensity pulsed ultrasound, magnetic field induction, growth factor therapy and the use of stem cells.⁴⁻⁶ The gold standard in the management of these fractures has been autologous bone grafting which involves removal of bone from the donor site and implantation at the site of delayed or nonunion. Autologous bone grafting has been the standard operative method for decades since the work of Plemister.⁷ Bone graft has the properties of osteogenesis, osteoinduction and osteoconduction which are beneficial in fracture healing. But it is an invasive procedure with its fair share of complications mainly at the donor site. Hence there has been a need for a minimally invasive procedure which promotes fracture healing and gives good functional results. In this scenario, percutaneous

autologous bone marrow injection has been quite successful as shown by various studies as available in literature. The osteogenic capacity of bone marrow was first demonstrated by Goujon in 1869 with his experimental studies performed on rabbits.⁸ Mc Gaw and Habin also confirmed the osteogenic properties of bone marrow in their studies.⁹ The concept of percutaneous autologous bone marrow injection in the management of these fractures was introduced by Herzog in 1955.¹⁰ Bone marrow is a good source of osteogenic progenitor cells such as osteoblasts, fibroblasts and reticular cells. These cells promote osteogenesis and bring about bone healing in cases of delayed and nonunion of fractures. The aim of this study was to evaluate the role of percutaneous autologous bone marrow injection in the management of delayed and non-union of long bone fractures and to compare the results with studies of other authors as available in literature.

METHODS

This was a study of 15 patients with delayed and non-union of long bone fractures treated with percutaneous autologous bone marrow injection at the Department of Orthopaedics, Saveetha medical college and hospital, Thandalam, between January 2013 to January 2015.

Skeletally mature patients with delayed and long union of long bone fractures willing for autologous bone marrow injection and for follow up were included in our study while skeletally immature patients, patients with active infection, malignancy and patients not willing for follow up were excluded. The patients were seen at the orthopaedic outpatient department and following admission a thorough history pertaining to the time since injury, previous surgical procedures performed, history of smoking and long term steroid use and the functional disability was taken and a physical examination was carried out. Any associated comorbid conditions were assessed and documented in the case records. The patients were then assessed radiologically by taking standard antero-posterior and lateral views of the affected limb and the status of the fracture was noted and documented. Standard definitions were used to classify fractures into being in a state of delayed or non-union. The FDA definition for non-union states that a minimum of 9 months has passed since the fracture with no visible signs of healing for the past 3 months. Clinical signs would be absence of pain at the fracture site with mobility on applying stress. Radiologically there would be lack of callus formation at the fracture site with sclerosis and tapering of the bone ends in the case of atrophic nonunions, while there would be varying amount of callus formation in the case of hypertrophic nonunions. Delayed union refers to a fracture that has not united in the time frame expected but continues to show progression for healing. Its characterized clinically by pain and tenderness at the fracture site on applying stress and radiologically there would be a visible fracture line with varying amount of callus formation. The patients

were taken up for the procedure under regional anaesthesia. A single dose of i.v. antibiotic was given at the time of induction of anaesthesia and oral antibiotics were given for a period of 3 days following the procedure. The recipient and the donor sites were painted and draped in the standard manner. A stab incision was made at the highest point in the ipsilateral ileac crest and a bone marrow biopsy needle was used to aspirate the bone marrow. Approximately 40 to 60 ml of marrow was aspirated from the ileac crest which was then injected at the site of delayed or non-union under fluoroscopic guidance. Heparin was not used routinely as the injection was performed immediately following aspiration. Following the procedure, the patients were discharged the next day and were asked to follow up at time frames of 1, 3, 6 months and at 1 year for functional and radiological assessment. All patients were instructed to use the affected limbs in a routine manner without any restrictions. All findings were recorded and documented. The data collected was analyzed using IBM SPSS Version 22.0. Armonk, NY: IBM Corp. Continuous variables were expressed as mean±SD and categorical variables were expressed as number and percentages. Chi square test was used in the comparison of categorical variables. A p value of less than 0.05 was considered to be statistically significant.

RESULTS

15 patients with delayed and nonunion of long bones treated with percutaneous autologous bone marrow injection were studied between January 2013 to January 2015. The mean age of the patients was 44.2 years ranging from 28 to 60 years (Table 1). There was a male preponderance in our study with the ratio of male to females being 2:1 (Figure 1). The left side was more affected as seen in 8 of our patients (Figure 2). Fractures of the tibial shaft were the most common as seen in 6 patients followed by femur, humerus, radius and ulna (Table 2). There were 11 patients with delayed union and 4 patients with nonunion (Table 3). The previous procedures performed were open reduction and internal fixation with plate osteosynthesis in 8 patients and interlocking intra medullary nailing in 7 patients (Table 4). There were 3 patients with grade 2 and 3 Gustilo and Anderson compound fractures which were initially managed by wound debridement and external fixator application which was converted into internal fixation after a period of 2 weeks. The mean time of presentation from the initial procedure was 5.8 months ranging from 4 to 10 months. The amount of bone marrow aspirated and injected at the fracture site ranged 40 to 60 ml with the mean being 46 ml. The mean time to radiological appearance of callus was 6.4 weeks ranging from 5 to 10 weeks. The mean time to clinical union was 7.33 weeks ranging from 6 to 12 weeks while the mean time to radiological union was 13.4 weeks ranging from 10 to 22 weeks (Table 5). Good clinical and radiological union was achieved in 14 of the patients in our study with one fracture of the humerus fixed with plating going in for

failure of union. All 14 patients with complete fracture union were happy with the procedure and the functional outcome. There were no complications like infection seen in our study. None of our patients were lost to follow up.

Table 1: Age distribution.

S. No.	Age of the patients	Number of cases	Percentage (%)
1	21-30	1	6.66
2	31-40	5	34
3	41-50	4	26.6
4	51-60	5	34

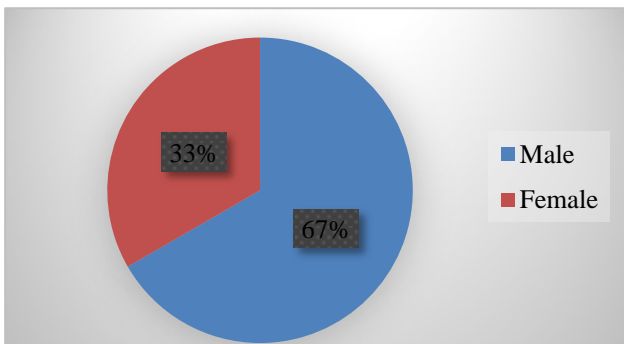


Figure 1: Sex incidence.

Table 2: Type of fracture.

S. No.	Type of fracture	Number of patients	Percentage (%)
1	Humerus	3	20
2	Tibia	6	40
3	Femur	3	20
4	Radius	2	13.34
5	Ulna	1	6.66

Table 3: State of union.

S. No.	State of union	Number of patients	Percentage (%)
1	Delayed union	11	73.34
2	Non union	4	26.66

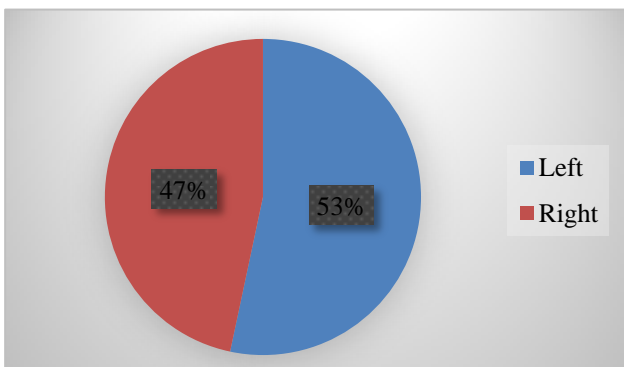


Figure 2: Side dominance.

Table 4: Initial treatment.

S. No.	Initial treatment	Number of patients	Percentage (%)
1	ORIF with plating	8	54.4
2	ILIM nailing	7	46.6

Table 5: Time to union.

S. No.	Type of union	Range (in weeks)	Mean time (in weeks)
1	Clinical union	6-12	7.33
2	Radiological union	10-22	13.4

DISCUSSION

The aim of management of delayed and nonunion of long bone fractures is to promote a solid union at the fracture site and to restore the functional capacity of the affected limb to an optimum level. Various noninvasive methods such as pulsed ultrasound, magnetic field induction and growth factor therapy are available and have been used with varying degrees of success. The gold standard of management of delayed and nonunion of these fractures has been autologous bone grafting which gives good results consistently. Bone grafting is an invasive procedure which is associated with its own set of complications, especially at the donor site such as painful scar, infection, haematoma formation, muscle herniation, fracture or subluxation and gait disturbances which have all been documented. These complications could bring about considerable morbidity for the patient and could also increase the expenditure to the patient and prolong the hospital stay. Hence there is the need for a procedure which is minimally invasive, cost effective, promotes good union at the fracture site and gives good functional results. In this scenario, percutaneous autologous bone marrow injection fulfills all the criteria and gives good functional results.¹¹⁻¹³

In our study, we had 15 patients with 11 having delayed union and 4 patients having nonunion of long bones. An average amount of 46 ml of bone marrow was aspirated and injected at the fracture site. The mean time to radiological appearance of callus was 6.4 weeks. The mean time to clinical union was 7.33 weeks and the mean time to radiological union was 13.4 weeks. We achieved a union rate of 93.3% with one fracture going in for failure of union. The fracture which failed to unite was a case of nonunion of fracture shaft of humerus which was treated with open reduction and internal fixation with plate osteosynthesis. It was a comminuted fracture with devitalized butterfly fragments which did not progress to union following bone marrow injection. It was managed with replating with bone grafting and eventually went in for union after 3 months. There were no complications either at the donor or the recipient site. All patients returned to their preinjury status at the end of 16 weeks

and were satisfied with the procedure and the functional outcome. None of our patients were lost to follow up.

Singh et al studied 12 patients with delayed and nonunion treated with percutaneous autologous bone marrow injection and they demonstrated good bony union at the fracture site in 10 out of 12 cases. The mean time to clinical union was 7 weeks and the mean time to radiologic union was 16 weeks.¹⁴ Elsattar et al studied 20 patients and reported good union in 16 patients (80%) and failure of union in 4 patients.¹⁵ Hau et al reported a 100% union rate in their study with all 10 patients achieving good bone union at the fracture site.¹⁶ We had a union rate of 93.3% in our study. A review of literature of other studies also showed good union rates following bone marrow infection which compares well with that of our study.¹⁷⁻²³

The limitations of our study could possibly be a small study group. A larger sample of patients would possible be essential to better consolidate and evaluate the effectiveness of this procedure. Through this study, we infer that percutaneous autologous bone marrow aspiration is a minimally invasive, cost effective and easily reproducible procedure in the management of delayed and nonunion of long bones. It has considerably low rates of morbidity as compared to traditional open bone grafting procedures and it reduces the expenditure to the patients while reducing the hospital stay and gives good functional results.

CONCLUSION

Percutaneous autologous bone marrow injection is a safe and reliable procedure in the management of delayed and nonunion of long bones. It is cost effective, easily reproducible and gives good functional results and is not associated with the potential complications seen in open bone grafting procedures. It is considered more effective in cases of delayed union as compared to nonunion.

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Ethical approval: The study was approved by the institutional ethics committee

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