

Original Research Article

Bone marrow concentrate efficacy in treatment of chronic aseptic nonunion

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ABSTRACT

Background: Bone marrow is a rich source of osteoprogenitor cells that proliferate and differentiate into osteoblasts. Traditionally, autologous iliac bone grafts have been used in treatment of nonunion. This technique has its associated morbidity, which include donor site pain, infection, scarring, and nerve injury. The use of percutaneous bone marrow stem cells (BMSC) avoids these morbidities with comparable clinical results.

Methods: We studied twenty patients of aseptic nonunion where bone marrow was aspirated from the anterior iliac crest, concentrated on a cell separator, and then injected into the nonunion site under c-arm guidance. Each nonunion received a relatively same amount of concentrated bone marrow. The volume of callus was calculated by dimensions obtained from RISPACS software in our institution.

Results: There was an average of 29,418 mm³ of callus formation with a minimum of 4,455 mm³ and maximum of 68,460. The average time of union was 12 weeks with minimum of 6 weeks and maximum of 24 weeks.

Conclusions: The percutaneous bone marrow concentrate injection provides an effective and a safe alternative method for the treatment of a chronic long standing non-union.

Keywords: Bone marrow injection, Delayed union, Non-union

INTRODUCTION

The healing of a fracture is a complex process which begins from the time of injury and continues for many years after achieving clinical and radiological union for the bone to attain its original structure and function. The main problems of concern a surgeon faces during fracture healing is of delayed union and non-union. Various methods of treatment have been adopted for this problem (e.g., electrical stimulation, ultrasound, bone transport and bone marrow).

The use of bone marrow in the treatment of non-union has its roots as early as 1934 when Harbin et al demonstrated the osteogenic activity of bone marrow.¹

Herzog et al suggested percutaneous bone grafting when he used a large bore needle and small cancellous chips to graft a non-union in 1951.²

Connolly et al after analyzing various methods and treatment for non-union with bone marrow aspirate found that the use of marrow cells injection around the non-union site can help in union.³⁻⁵

Since the initial use of bone marrow cells various other application have been described with promising results such as a the treatment of simple bone cysts and in the management of congenital tibial pseudoarthrosis.^{6,7} The aim of this study was to assess the results of percutaneous bone marrow injection in the treatment of chronic aseptic non-union of long bones.

METHODS

This prospective study was done in Sri Ramachandra Medical College between April 2017 to June 2018. The study included twenty consecutive patients who presented to our OPD with chronic aseptic non-union of long bones including femur, tibia and humerus. The fracture was considered none united when there was no progression of union over the last three months, with a time lapse of more than six months since internal fixation. Non-union was defined as no radiographic evidence of union at the fracture site over three months, following six months after index surgery.

The inclusion criteria were all patients who presented with non-infected non united fracture of the long bones. Patients who presented with infected or gap non-union were excluded from the study. The injection time interval between the index surgery and the bone marrow injection ranged from 4 to 22 months with an average of 9.5 months. The study included twelve tibia fractures, six femoral fractures and two humerus fractures.

Bone marrow aspirate is prepared in two separate stages. Firstly, bone marrow needs to be aspirated from the anterior iliac crest using a bone marrow aspiration needle which has been heparinized to avoid clotting of the aspirate; around 60 ml of aspirate is taken. Secondly, the aspirate is then concentrated with the help of a centrifuge at the speed of 3200 rpm for 15 mins. This will give us a sample in which the bone marrow cells are at the bottom while plasma is at the top of the tube. This plasma layer is carefully removed without disturbing the cells to obtain a concentrate of bone marrow cells of nearly 10 ml. This was injected percutaneously into and around the fracture site under fluoroscopy control.

All patients were discharge the same day following the procedure. Clinical union was assessed by the ability of the patient to weight bear unsupported for the lower limb fracture or to use the upper limb in daily activities without any pain or tenderness at the fracture site. Radiological union of the fracture was assessed through serial monthly plain radiographs. Postoperatively we used radiograph to measure the volume of callus formed by dimensions obtained from RISPACS software in institution.

RESULTS

Out of 20 patients males are 45% and females are 55%. Majority are in the age groups of 50-55 years (60%), followed by 55-60 years (40%).

We passed the chronicity of the non-union, time taken for union to achieve following the injection and the volume of callus formation. In all twenty of our patients we achieved clinical and radiological non-union. The patients were all mobilized full weight bearing with no support and reported to tenderness at the non-union site. The time to union following the injection ranged from 6 to 24 weeks at an average of 12 weeks. The volume of callus was calculated with the help of RISPACS software which was available in our institution. All post-operative radiographs were measured for the callus length and breadth. The volume of callus was calculated ($L \times B$). There was an average of 29,418 mm³ of callus formation with a minimum of 4,455 mm³ and maximum of 68,460. None of the patients had any infection. No other complications regarding the donor site or the injection site was reported by any of our patients.

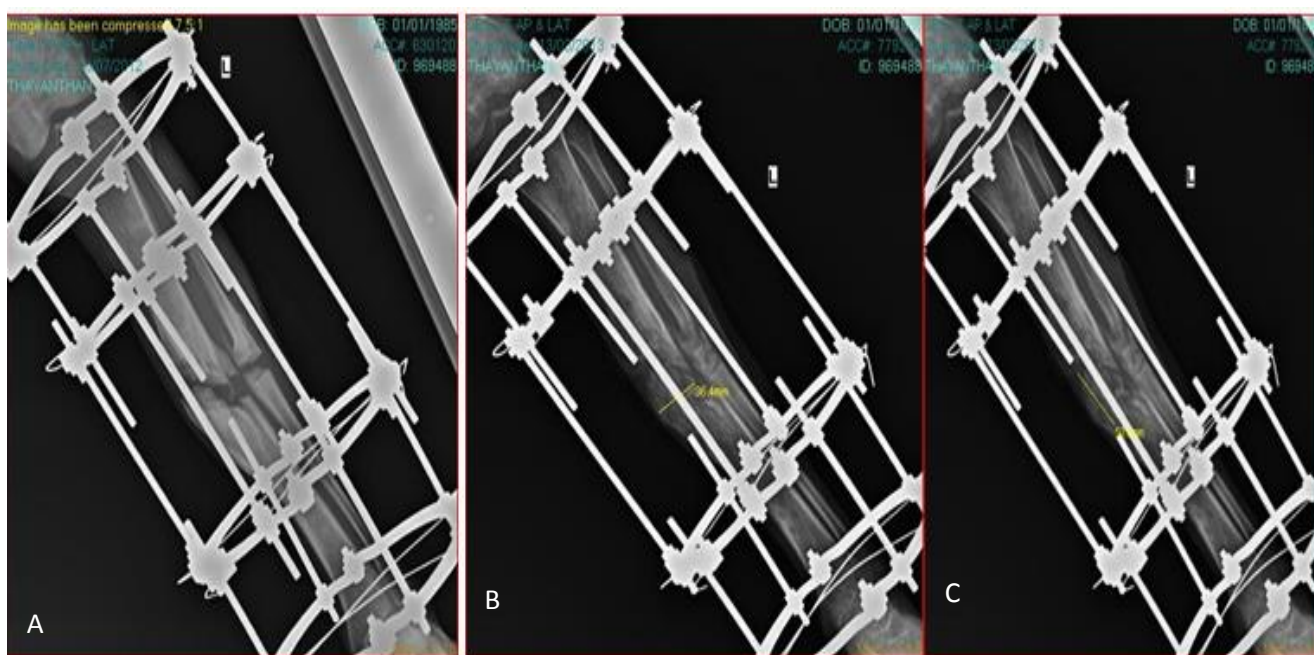


Figure 1: (A) Nonunion of tibia at the time of presentation, (B) united fracture where callus breadth and (C) length.

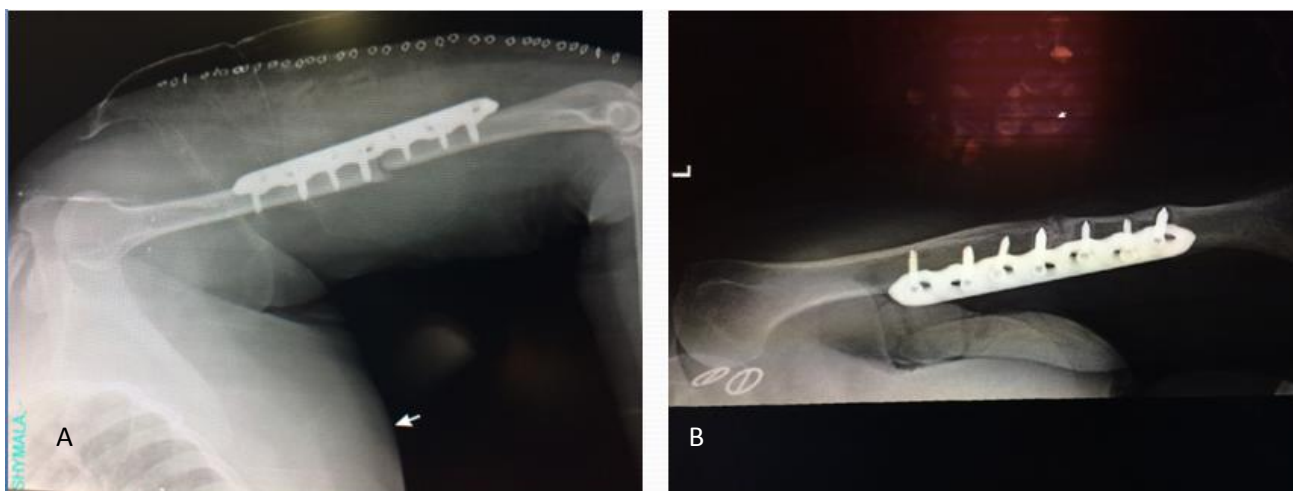


Figure 2 (A and B): Non-union humerus treated by bone marrow aspirate concentrate injection.

Table 1: Findings of the study (n=20).

Variables	N (%)
Sex	
Male	9 (45)
Female	11 (55)
Age (in years)	
50-55	12 (60)
55-60	8 (40)
Volume of callus (mm³)	
Max	68460
Min	4455
Avg	29418

DISCUSSION

The problem of non-union is challenging for most surgeons. The most common method of management has been surgical management with open grafting. This is often complicated by donor site complications like haemorrhage and infection, the need for an secondary surgical procedure, and can disturb the vascularity of the fracture site.^{8,9}

Various lesser invasive techniques good results and lesser complication like pulsed low intensity ultrasound, extracorporeal shock waves and bone growth factors.^{10-12.}

In our study we found that ten out of the fifteen male patients were smokers. None of the female patients were smokers. The time to union after bone marrow injection was longer in smoking patients compared to non smoking patients. This relation was however not statistically significant. The relation between smoking and non-union of fractures has been reported in several previous studies.¹³⁻¹⁵

The tibia represented 60% of the cases in this study. The relatively high incidence of non-union associated with tibial fractures compared to the other long bones fractures

has also been reported in previous studies.^{16,17} This is probably due to the subcutaneous anatomical location and poor vascularisation of the lower limb.

In this study, we had a case of nine month non-union of tibia following a Grade IIIB injury leading to the patient requiring Illizarov fixation. We found that the non-union healed in twelve weeks following the injection (Figure 1). Similarly a non-union of 4 months of humerus we found that the fracture healed within 6 weeks following the injection (Figure 2). Hence time of presentation plays a role in early union of the fracture.

Various other authors have recommended the use of concentrated bone marrow obtained by centrifugation in order to increase the number of osteoprogenitor cells in the bone marrow injected.^{18,19}

Muschler et al reported a 95% success rate when he increased the concentration of the cells in the aspiration volume.²⁰ He recommended the aspiration of bone marrow from multiple sites to avoid dilution with the peripheral blood.

The role of bone marrow aspirate in various other clinical situations such infection, pathological fractures, and in nonunion of smaller bones like metatarsals with good results.^{5,18,19,21}

None of the studies reported any complications associated with the donor site or the injection site.

CONCLUSION

Autologous marrow grafting is a simple and minimally invasive technique of providing bone osteogenic cells without the complications or risks of cancellous bone grafting. We recommend the use of this procedure as an early intervention when delayed union of a fracture is suspected. We recommend the use of percutaneous autologous bone marrow concentrate in patients with

aseptic nonunion for their management with excellent results.

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Conflict of interest: None declared

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

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