

## Original Article

### ASSESSMENT OF EFFICACY OF PERCUTANEOUS AUTOLOGOUS BONE MARROW INJECTION IN CASES OF DELAYED UNION AND NON-UNION FRACTURES

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**Background:** Cells aspirated from bone marrow are being shown to provide stimulus for osteogenesis in animal experiments and in clinical evaluation of bone graft and bone substitutes. The present study was planned to assess the efficacy of percutaneous autologous bone marrow injection in cases of delayed union and non-union fractures. **Materials and methods:** The study was conducted in the department of orthopedics and department of general pathology of the medical institute. In the study period, we treated 12 patients with long bone fractures with this procedure for delayed union (n=9) or non-union (n=3). Follow up after every 4-6 weeks was done to assess clinically and radiographically the rate of healing of bone. In current study, Union potential grading systems was employed. **Results:** Excellent union potential score was awarded to 2 patients, good score was awarded to 9 patients and poor score was awarded to only 1 patient. Out of 2 patients with excellent score, union was achieved in both the patients. Out of 9 patients with good score, union was achieved in 7 patients only. Union was not observed in case of patient with poor score. **Conclusion:** The autologous marrow grafting is an effective method for reactivation of osteogenesis. Fracture cases with excellent union potential score had maximum probability of union. **Keywords:** Bone marrow, fracture, healing, osteogenesis.

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#### INTRODUCTION:

The treatment of nonunion continues to be a major challenge in orthopedic surgery. An estimated 5% to 10% of fractures result in delayed or nonunion causing patients to endure impaired function as well as repeated hospitalizations and surgeries.<sup>1</sup> Bone marrow aspirate (BMA) has been utilized as a source of bone marrow-derived mesenchymal stem cells (BM-MSC) with its relative ease of harvest, low morbidity, and feasible cost. BMA alone has a relatively low percentage of MSCs with only 0.001% to 0.01% of all nucleated cells in BMA being MSCs. Therefore, the aspirate is typically concentrated by centrifugation in order to increase the

ratio of MSCs.<sup>2, 3</sup> Concentrated bone marrow aspirate (cBMA) provides both stem cells and growth factors and relies on the host tissue to provide scaffold. The use of cBMA has become an increasingly popular alternative and adjunct in the treatment of cartilaginous lesions, bony defects, and tendinous injuries.<sup>4</sup> Cells aspirated from bone marrow are being shown to provide stimulus for osteogenesis in animal experiments and in clinical evaluation of bone graft and bone substitutes. Despite this osteogenic characteristic, the clinical use of marrow as an osteogenic source has remained limited.<sup>5</sup> The marrow is harvested by needle aspiration from the patient's pelvic bone and is then injected percutaneously at the

nonunion site.<sup>6</sup> This method offers the advantage of treating fracture-healing problems without operative exposure of either the donor or recipient site. Hence, the present study was planned to assess the efficacy of percutaneous autologous bone marrow injection in cases of delayed union and non-union fractures.

**MATERIALS AND METHODS:**

The study was conducted in the department of orthopedics and department of general pathology of the medical institute. The ethical clearance for bone marrow injection the study was obtained from the ethical committee of the institute. An informed signed consent was obtained from the all the participants. In the study period, we treated 12 patients with long bone fractures with this procedure for delayed union (n=9) or non-union (n=3). On the basis of location of fracture, 2 patients had fracture of femur shaft, 1 patient had fracture of shaft ulna and other 9 patients had fracture of tibia shaft. All the patients were treated conservatively and advised partial weight bearing for 8-16 weeks. Now, after mean time period of 25 weeks (7-42 weeks), patients were subjected to bone marrow injection. One injection was satisfactory in preponderance patients. The standard technique adopted for aspiration of bone marrow was from anterior iliac blade and injecting percutaneously. 16 gauze bone marrow aspiration needle was used for aspiration and injection at fracture site. In fracture cases of tibia and femur, about 50-90 ml volume of bone marrow was injected whereas in case of fracture of ulna, 15 ml of bone marrow was injected. The marrow was aspirated in 5-10 ml aliquots and injected at the fracture site simultaneously. Multiple entry portals were needed on one or both the iliac crests to harvest the marrow.

Postoperatively compression band was given for 2-3 days. Further management of the fracture site was

done and patient was motivated to keep the bane mobile. Follow up after every 4-6 weeks was done to assess clinically and radiographically the rate of healing of bone. In current study, Union potential grading systems was employed.

Union potential grading system is based on following criteria:

1. Initial displacement.
2. Comminution.
3. Soft tissue injury,
4. Wound infection,
5. Alignment

Maximum score awarded was 15. If the scoring of a case was 13 or more, tremendous union of fracture fragments is predictable. Similarly, a score of 9-12 reflect good probability of union as well as non-union or delayed union. A score below 9 reflects unpredictable union results and high chances of delayed or non-union. The results were noted and analysed.

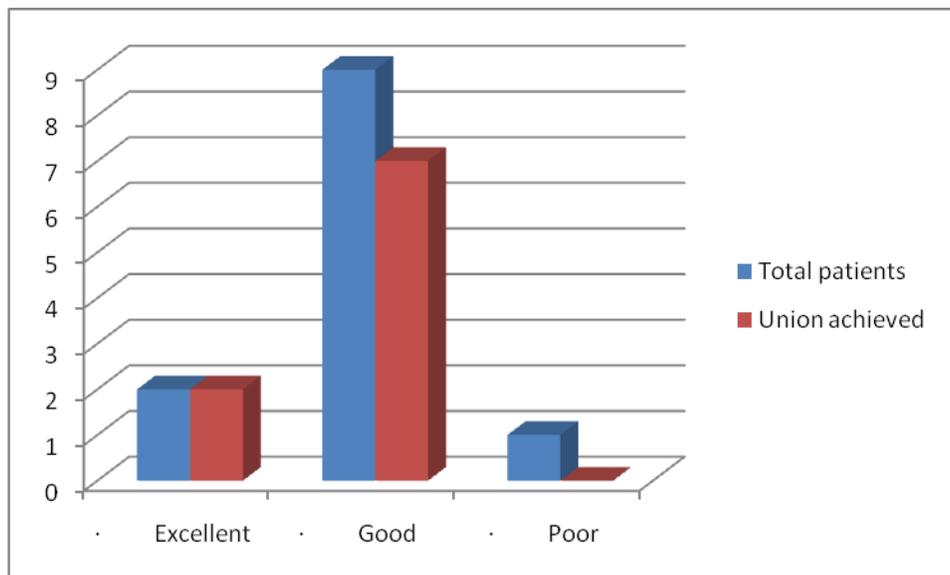
The statistical analysis of the data was done using SPSS software for windows. Chi-square test and student’s t-test were used for testing statistical significance of the data. A p-value of 0.05 or lesser was predefined to be statistically significant.

**RESULTS:**

**Table 1** shows the number of patients under each group and number of patients in which union was achieved. Excellent union potential score was awarded to 2 patients, good score was awarded to 9 patients and poor score was awarded to only 1 patient. Out of 2 patients with excellent score, union was achieved in both the patients. Out of 9 patients with good score, union was achieved in 7 patients only. Union was not observed in case of patient with poor score [**Fig 1**]. The results were non-significant (P>0.05).

**Table 1:** Union potential score of patients and number of patients with union achieved

Union potential score	No. of patients	
	Total participants	Union achieved
• Excellent	2	2
• Good	9	7
• Poor	1	0
<b>Total</b>	<b>12</b>	<b>9</b>



**Figure 1:** Showing union potential score of patients and number of patients with union achieved

**DISCUSSION:**

Skeletal healing is primarily a biological process, and depends upon cellular response. The most productive source of cells that influence osteogenesis is considered to be autologous marrow. In the present study we assessed the efficacy of percutaneous autologous bone marrow injection in cases of delayed union and non-union fractures. In the present study, we observed that patients with excellent union potential score had the highest probability of union of fracture elements. Similarly, patients with poor union potential score had lowest probability of union of fracture fragments. The results were consistent with studies by other researchers. Sim R et al conducted a retrospective study of the use of autologous bone marrow injection for the treatment of delayed and non-union of long bones in an Orthopaedic Department, Singapore General Hospital from 1990-1991 is presented. There were 10 patients with 11 fractures (8 tibia and one each of humerus, femur and radius-ulna) available for study. Percutaneous injection of autologous marrow alone was used to stimulate healing of delayed and non-unions treated initially by plating, external fixation and in one case, by plaster cast. Marrow injection stimulated a callus formation sufficient to unite 9 of the fractures. The median time to clinical union was 10 weeks (range 4-23 weeks) and radiological union 17 weeks (range 9-29 weeks). Most patients had discomfort at the donor and injected sites

for one to two days. There was one case of infection but none of the significant donor site morbidity was associated with standard open autologous grafting. Kassem MS assessed the results of percutaneous injection of autologous bone marrow in the treatment of fractures presenting with delayed union or non union after internal fixation. Twenty consecutive patients presenting to our outpatient clinic with internally fixed fractures with delayed union or non union were included in the study. The time between the index surgery and the bone marrow injection ranged from 4 to 24 months with a mean of 9.65 months. The bone marrow aspirate was injected percutaneously into the fracture site under fluoroscopy control. Nineteen out of the twenty fractures achieved clinical and radiological union, on average after 2.95 months. In this series, percutaneous bone marrow injection appeared as a simple and effective method to accelerate fracture healing in patients with delayed union and nonunion of fractures.<sup>7,8</sup>

Li Y et al investigated the effect of treatment of humeral shaft nonunion with interlocking nail and percutaneous injection of bone marrow after operation. Twenty-five adult patients with humeral shaft nonunion, initially treated with plates, intramedullary nails, or external fixators changed to use RussellTaylor reamed antegrade intramedullary nails with autologous bone grafting and percutaneously bone marrow injection into the fracture sites ten days after the

operation to promote union. All patients achieved a solid union with good function. The union period was a median of 4.5 months. They believe that the procedure may provide firm internal fixation and improve activity of osteoblasts in fracture sites for accelerating fracture healing. Hernigou P et al evaluated the number and concentration of progenitor cells that were transplanted for the treatment of nonunion, the callus volume obtained after the transplantation, and the clinical healing rate. Marrow was aspirated from both anterior iliac crests, concentrated on a cell separator, and then injected into sixty noninfected atrophic nonunions of the tibia. Each nonunion received a relatively constant volume of 20 cm<sup>3</sup> of concentrated bone marrow. The number of progenitor cells that was transplanted was estimated by counting the fibroblast colony-forming units. The volume of mineralized bone formation was determined by comparing preoperative computerized tomography scans with scans performed four months following the injection. There was a positive correlation between the volume of mineralized callus at four months and the number and concentration of fibroblast colony-forming units in the graft. There was a negative correlation between the time needed to obtain union and the concentration of fibroblast colony-forming units in the graft. They concluded that percutaneous autologous bone-marrow grafting is an effective and safe method for the treatment of an atrophic tibialdiaphyseal nonunion.<sup>9,10</sup>

### CONCLUSION:

From the results of present study, we conclude that autologous marrow grafting is an effective method for reactivation of osteogenesis. Fracture cases with excellent union potential score had maximum probability of union.

### REFERENCES:

1. Hierholzer C, Sama D, Toro JB, Peterson M, Helfet DL. Plate fixation of ununited humeral shaft fractures: Effect of type of bone graft on healing. *J Bone Joint Surg Am.* 2006;88(7):1442–1447.
2. Pittenger MF, Mackay AM, Beck SC, Jaiswal RK, Douglas R, Mosca JD, Moorman MA, Simonetti DW, Craig S, Marshak DR. Multilineage potential of adult human mesenchymal stem cells. *Science.* 1999;284:143–147.
3. Kennedy JG, Murawski CD. The Treatment of Osteochondral Lesions of the Talus with Autologous Osteochondral Transplantation and Bone Marrow Aspirate Concentrate: Surgical Technique. *Cartilage.* 2011;2:327–336.
4. Connolly J, Guse R, Lippiello L, Dehne R. Development of an osteogenic bone marrow preparation. *J Bone Joint Surg* 1989;71-A or B:684-91. Back to cited text no. 7
5. Burwell RG. Studies in the transplantation of bone. vii. the fresh composite homograft-autograft of cancellous bone: An analysis of factors leading to osteogenesis in marrow transplants and in marrow-containing bone grafts. *J Bone Joint Surg* 1964;46-B:110-40.
6. Hernigou P, Poignard A, Beaujean F, Rouard H. Percutaneous autologous bone-marrow grafting for nonunions. Influence of the number and concentration of progenitor cells. *J Bone Joint Surg* 2005;87-A:1430-7
7. Sim R, Liang TS, Tay BK. Autologous marrow injection in the treatment of delayed and non-union in long bones. *Singapore Med J.* 1993 Oct;34(5):412-7.
8. Kassem MS. Percutaneous autogenous bone marrow injection for delayed union or non union of fractures after internal fixation. *ActaOrthop Belg.* 2013 Dec;79(6):711-7.
9. Li Y, Shi S, Liu Z, Li Z, Wang R, Guo Y, Chang H. Treatment of humeral shaft nonunion with interlocking nail and percutaneous injection of bone marrow. *ZhonghuaWaiKeZaZhi.* 2000 Oct;38(10):732-5, 42.
10. Hernigou P, Mathieu G, Poignard A, Manicom O, Beaujean F, Rouard H. Percutaneous autologous bone-marrow grafting for nonunions. Surgical technique. *J Bone Joint Surg Am.* 2006 Sep;88Suppl 1 Pt 2:322-7.

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