Role of Percutaneous Autologous Bone Marrow Grafting In Non-union Tibia

Faaiz Ali Shah, Zahir Khan, Zulfiqar Ali Durrani, Ismatullah, Kifayatullah, Haziqdad Khan

ABSTRACT

Objective
To evaluate the efficacy of percutaneous autologous bone marrow grafting in patients with tibial diaphyseal non-union.

Study design
Descriptive case series.

Place & Duration of study
Orthopaedic Surgery Unit, Mardan Medical Complex Teaching Hospital, Bacha Khan Medical College Mardan, from March 2011 to October 2012.

Methodology
Fifteen patients (mean age 41.6 year) with tibial non-union were treated with a single percutaneous autologous bone marrow injection. The bone marrow was aspirated from the anterior iliac crest and injected at fracture site. The procedure was carried out under general or spinal anesthesia. The patients were followed up after every four weeks and the rate of healing was assessed clinically as well as radiologically. Union Scale Score was used to assess the progress of union. A score of six or more was considered as sound union.

Results
Majority (73.3%, n=11) of the patients achieved a solid union after an average period of 14 weeks (range 12 -20 weeks). Four (26.6%) patients however could not achieve union. The average time duration between the procedure and injury was 37 weeks (range 36-40 weeks). The average pre injection Union Scale Score was 2 (0-3). The mean Union Scale Score at the end of study was 5.8 (0-7) and in united cases it was 6.4 (6-7).

Conclusion
Percutaneous autologous bone marrow injection provided an effective safe and easy bone grafting in non-union tibia.

Key words
Percutaneous grafting, Bone marrow, Non-union tibia, Bone graft.

INTRODUCTION:
The prevalence of non-union of closed tibial shaft fractures is 2.5% and increases 5-7 fold for open fractures with gross contamination and extensive soft tissue damage.\(^1\) Surgical management with debridement of necrotic tissue and rigid fixation (either internal or external) along with a form of biological enhancement, such as bone grafting, is considered the ‘gold standard’ for the treatment of non unions.\(^2\)

Investigators have demonstrated that when access to local bone marrow is prevented, bone healing is minimal leading them to hypothesize that bone marrow precursor osteoblasts and mesenchymal stem cells synergistically act with bone morphogenic proteins to produce an effective healing response.\(^3\) McGaw and Harbin were among the first to demonstrate the osteogenic activity of bone marrow.\(^4\)

The concept of percutaneous bone grafting was introduced by Herzog in 1951.\(^5\) He used a large bore needle and small cancellous chips to graft a non-union. Since bone marrow has a liquid texture, combining the percutaneous grafting technique introduced by Herzog and the bone marrow graft introduced by McGaw appears logical.\(^5,4\) The marrow is harvested by needle aspiration from the patient’s pelvic bone and is then injected percutaneously.
at the non-union site.

The purpose of this study was to ascertain the osteogenic potential of percutaneous autologous bone marrow injection and its effectiveness in the management of non-union tibia.

METHODOLOGY:
In this study patients of both gender and all ages with established atrophic tibial diaphysial non-union were admitted to Orthopaedic Unit, Mardan Medical Complex Teaching Hospital & Bacha Khan Medical College Mardan, from April 2011 to October 2012. The following criteria were used for inclusion in this study:

Patients in whom no surgical / treatment intervention was done for non-union in the past 3 months, without evidence of active infection, no smoking for 6 weeks before the treatment period, no concurrent interfering medications use such as cortisone preparations or anti metabolic drugs, and fractures with acceptable alignment and good bony apposition, were included.

Non-unions of the tibial shaft were defined as radiologically confirmed unhealed shaft fractures at least 9 months following the injury and treatment. Relevant history, clinical examination and x-rays of the limb were done. Full blood count, ESR and CRP were done to exclude infection. All patients were fully informed with respect to the rationale of the study and the associated risks, in accordance with a protocol and the signed consent form approved by the Institutional Review Board.

The standard procedure of aspiration of bone marrow from the anterior iliac crest and injecting percutaneously at fracture site was adopted. With the patient in supine position, both donor iliac crest(s) and recipient area were draped separately. The procedures were done under general or spinal anesthesia. A bone marrow aspiration needle (sternal puncture needle) was used to aspirate bone marrow from the iliac crest with a non-heparinized 10 ml syringe. In each tap 3-4 ml marrow was aspirated and simultaneously injected with a 16 gauge lumbar puncture needle into the recipient area. Image intensifier was used to locate the area of bone marrow injection. The volume of bone marrow injected was 15-20 ml. After the injection the donor area was covered with pressure bandage only and the recipient site was immobilized in plaster of Paris cast.

Weight-bearing was not allowed during the first month after the bone-marrow injection. After one month, and only when callus was observed on x-rays, partial weight bearing was allowed with plaster or external fixation. The patients were followed up after every four weeks and the rate of healing was assessed clinically as well as radiologically. Union Scale Score, a numerical score was used to assess the progress of union (table I). A score of six or more was considered as sound union. A period of one month between the beginning of partial weight-bearing and full weight-bearing (close to physiological level) was observed. At that time, if the patient had no pain and if there was cortical bridging or disappearance of the fracture lines on at least three of the four cortices viewed on the anterior posterior and lateral radiographs, the plaster or the external fixator was removed.

RESULTS:
A total of 15 patients with mean age 41.6 year (range 23-60 year) completed the study. Eleven (73.3%) patients were males and 4 (26.6%) females. Right tibial non-union was present in 10 (66.6%) patients while left tibia was involved in 5 (33.3%) cases. Non-union sites were proximal tibial diaphysis in 4 (26.6%) patients, mid shaft in 8 (53.3%) and

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DISCUSSION:

Percutaneous autologous bone marrow grafting is a useful technique in the treatment of non-unions. In this study majority of the patients achieved a solid union after an average period of 14 weeks. These results are more or less similar to other studies. Goel and Sangwan reported clinical and radiological bone union following percutaneous injection in 75% patients, with an average time to union following the first injection of 14 weeks. They concluded that percutaneous bone marrow grafting is a safe, simple, and reliable method of treating tibial non-union with minimal deformity. The procedure, however, was carried out under local anesthesia in their study.

Connolly reported the results of autogenous marrow injection in treating twenty un-united tibial fractures over a five-years period with union of eighteen out of the twenty cases (90%). Another study reported that bone marrow stimulated callus formation sufficient to unite thirteen (92.8%) out of fourteen tibial non-unions. Bone marrow injection was as effective as open autogenous grafting but with considerably less complications. Thus, the technique provides a reliable source of osteogenic stem cells with numerous advantages compared with standard open grafting techniques. In our study 15-20 ml of bone marrow was aspirated from the posterior iliac crest and injected at the fracture site twice with an interval of three weeks, while we used a single bone marrow injection to treat tibial non-unions.

In a study by Bhargava and Sankhla, 25 tibial shaft delayed union and non-union were treated with autologous bone marrow injection and reported that one injection was found to be sufficient in majorit of cases, whereas in five cases the procedure was repeated. They concluded that this method can be used as an early intervention, whenever one suspects a delay in the healing of fracture. This study, like ours used Union Scale Score to assess the progress of union after bone marrow injections.

Another study involving 11 (8 tibial non-unions) patients with delayed union and non-union of fractures reported that after treatment with bone marrow injection, nine fractures united within an average of 10 weeks clinically and 17 weeks radiographically. Bone marrow injection was effective in stimulating bony union, with numerous advantages and considerably lower morbidity compared with standard open autologous grafting. Shorter inpatient stay was a significant feature.

Siwach and Sangwan achieved bony union in 68 of 72 cases of delayed unions and non-unions while four patients failed to achieve union despite three injections. Overall assessment of the results showed 52 excellent results (72.2 %), 8 good (11.1 %), 8 fair (11.1 %) and 4 (5.5 %) failure and they suggested that percutaneous autogenous bone marrow grafting is a simple, safe and useful technique in the treatment of delayed unions and non-unions. This procedure can also be useful in iatrogenic delayed or non-unions which is the commonest cause of nonunion in present era of enthusiastic fracture fixation. They believe that this technique of percutaneous autogenous bone marrow grafting can be a procedure of choice in those patients where Phemister or Forbes methods of bone grafting alone are required, especially in limbs with scarred and poor soft tissue coverage.

We used 15-20 ml of non-heparinized autologous bone marrow aspirates in our study. Heparin was not required in our study because of the short interval between aspiration and injection, thereby avoiding the potential impairment of bone healing associated with heparin reported by Stinchfield et al. No definitive conclusion can be made regarding the amount of marrow to be injected because different investigators have injected different amounts of bone marrow with good results but now it has been shown that efficacy of injected marrow is directly associated with heparin reported by Stinchfield et al. No definitive conclusion can be made regarding the amount of marrow to be injected because different investigators have injected different amounts of bone marrow with good results but now it has been shown that efficacy of injected marrow is directly
related to the number of progenitor cells. Larger-volume aspirates contribute little to the overall number of bone marrow cells and result principally in unnecessary blood loss. Bhargava used 50-90 ml of bone marrow aspirates in his study, Garg used 15-20 ml, Healey 50 ml, Connolly 100-150 ml, while Ahmad injected 15-20 ml of marrow in his cases.

Connolly was the first to evaluate the possibility of improving the efficacy of an aspirated bone-marrow graft by concentrating marrow-derived cells. He found a significant increase in bone formation within diffusion chambers implanted in vivo in the rabbit. Subsequently, limited clinical experience has been reported using intra-operative centrifuging of marrow for grafting. In our experience, percutaneous autologous bone marrow cell grafting is an efficient and safe method of treatment of non-infected atrophic non-unions. Although this technique did not promote more rapid healing than classic open surgical grafting, it offered the benefits of decreased morbidity, reduced cost, and shorter hospital stay.

Like all techniques, it has its limitations. It cannot be used when there are pre-existing angular deformities or prior shortening, which require direct access to the non-union, making percutaneous injection of the bone marrow impossible. As the volume of callus obtained with this technique was limited, the gap and the displacement of the fragments should also be limited. Protocols will be needed to standardize aspiration techniques that are most likely to optimize the number and concentration of osteoblast progenitor cells that are obtained. We also must investigate the possibility that the processing of bone marrow before injection may improve the outcome of bone healing. Unfortunately, almost no randomized controlled trials or large case series are performed on this topic. Larger controlled series or randomized controlled trials are needed to evaluate the role of bone marrow as a material for bone grafting in tibial non-unions.

CONCLUSIONS:
Percutaneous autologous bone marrow injection provided an effective, safe and easy alternative to open bone grafting in non-union tibia. The high risk patients of established non-unions with poor soft tissue coverage are particularly suited to the percutaneous bone marrow grafting technique. In addition, this was a good procedure for patients with high risk for anesthesia or the cases who are in waiting list for any definitive surgical procedures. Bone marrow aspiration from the iliac crest did not limit rehabilitation, and did not cause a delay in discharge from hospital.

REFERENCES:


