Percutaneous bone marrow grafting for the treatment of tibial non-union

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Accepted 16 January 2004

\textbf{Introduction}

Non-union is still a major challenge to the orthopaedic surgeon.\textsuperscript{14} Stabilization and open bone grafting are the basic principles in the treatment of fracture non-union; however, infection is always a concern.\textsuperscript{11} To minimize this risk, percutaneous bone marrow grafting has been suggested as an alternative, this provides a source of osteogenic cells with an osteoinductive effect.\textsuperscript{3,5,7,9}

The aim of this study is to assess prospectively, the efficacy of percutaneous bone marrow grafting in patients with established tibial non-union, whilst on the waiting list for open surgical bone grafting and stabilization.

\textbf{Patients and methods}

The study was conducted at a tertiary referral centre with a rural catchment area from northern India. We recruited 20 consecutive patients who were on the waiting list for open bone grafting...
with established tibial non-union and minimal deformity.

Non-union was diagnosed clinically when there was persistent pain, tenderness and motion at the fracture site for more than 24 weeks. This was confirmed radiologically with no evidence of progression to bone healing on repeat X-rays for at least 3 consecutive months. All the radiographs were reviewed by the senior author who has more than 20 years experience in traumatology.

Inclusion criteria were healthy patients over 18 years of age with definite tibial non-union and minimal deformity, who were scheduled for open bone grafting and consented for this study. Exclusion criteria were infection, deformity more than 10° angulation and internal fixation in situ. There were 16 males and 4 females in the study; their average age was 37.5 years (range: 24–60). Three were open fractures which were managed initially with mono-lateral external fixator, then were changed to below knee weight bearing plaster cast. All the other patients were treated conservatively with above knee plaster cast initially then were changed to below knee weight bearing cast. Six patients had more than one fracture (one of the other tibia, two of the humerus, three of the forearm). Fourteen patients had no other injuries. The average period from fracture to diagnosis of non-union was 12 months (range 6–36).

Ten fractures were hypertrophic and 10 were atrophic non-unions according to Judet and Judet classification (Table 1). The more detailed Weber and Cech classification was not used. Our atrophic variety would be the oligotrophic non-union as per the Weber and Cech system. All patients used NSAID’s for pain relief.

Bone marrow was obtained from the iliac crest, and injected immediately into and about the non-union site. Injections were repeated at 4–6 weeks if there was no radiological evidence of callus formation. The procedure was considered a failure if there was no clinical and radiological union at 6 weeks following the third injection.

Union was defined clinically as absence of tenderness and movement on stressing the fracture site, in addition to normal full weight bear without pain. Radiologically, union was confirmed if there was a bridging callus on at least three cortices on radiographs in two planes. All patients were followed up and assessed clinically and radiologically by one person. Radiographs were collected and analysed by one observer and confirmed by the senior author.

Table 1 The demographic and clinical data of 21 patients with tibial non-union treated with percutaneous bone marrow grafting

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Mean 37.5 11.7 2.3 3.3

a Site of fracture: u, upper; m, middle; l, lower third of tibia.
b Type of non-union: a, atrophic; h, hypertrophic.
c Duration of non-union: months.
d Results: y, united; n, failure.
Operative technique

The injection of bone marrow was performed as an outpatient procedure under local anaesthesia. Following formal consent, with the patient supine, both iliac crests and the non-union site were prepared and draped in a sterile manner. One percent lignocaine was infiltrated into the skin down to the periosteum. The fracture non-union site was approached from the antero-lateral aspect with a 16 Gauge spinal needle, which was left in situ. Bone marrow was aspirated from the iliac crest 1 cm posterior to the anterior superior iliac spine. Marrow of 3–5 ml was aspirated and injected immediately into and about the non-union site. Subsequent aspirations were performed 1 cm posterior to the previous site until a maximum of 15 ml of marrow was aspirated and injected.

Patients with a proximal third fracture went into an above knee plaster cast and lower two third fracture into a patellar tendon bearing cast. Patients were encouraged to mobilise full weight bearing. Radiographs were repeated at 4–6-week interval.

Results

One patient was lost to follow up. Nineteen patients were followed up clinically and radiologically until definite bone union or failure.

Bone union following percutaneous bone marrow injection was achieved in 15 out of 20 patients (75%) Figure 1. The average time to union following the first injection was 14 weeks (range 6–22). Two of them needed only one injection, nine needed two injections, and four patients needed three injections to unite. Four patients (20%) showed no evidence of union and were considered a failure and their planned surgical treatment (open bone grafting) was performed (Table 1). One of these failures was a hypertrophic non-union, and three were atrophic. There were no cases of infection following the percutaneous injection, and no complications at the donor site.

Discussion

Non-union was defined by the FDA panel as established when a minimum of 9 months has elapsed since injury and the fracture shows no visible progressive signs of healing for 3 months. These criteria have been modified, as it is often difficult to put a fixed time period to the definition.11,13 Taylor13 stated that the criteria of 9 months cannot be applied to every fracture and suggested that fracture non-union of long bones could be considered when it is a minimum of 6 months and did not show any progression towards union. Our criteria for defining non-union were persisting pain and mobility at the fracture site for a minimum period of 6 months from injury, in addition to non-progression on 3 monthly serial radiographs. All the five patients at 6 months were of the atrophic type.

Numerous techniques of bone grafting have been described for the treatment of non-union. These include:

(a) onlay bone grafting with internal fixation by Campbell;2
(b) onlay bone grafting without internal fixation by Phemister;10
(c) subcortical iliac bone graft by Forbes DB;4
(d) Boyds dual onlay grafts;1
(e) cancellous insert grafts by Nicoll EA.8
Percutaneous autologous bone marrow grafting is being used as an alternative to the open technique with negligible complications in the treatment of tibial non-union. There are only a few reports in the literature in support of this technique and its potential benefits. This was confirmed experimentally by Paley et al., when he demonstrated the definite effect of bone marrow grafting in stimulating bone healing of non-union model in rabbit radii.

Percutaneous bone marrow grafting is a simple technique as marrow can be aspirated and injected as an outpatient procedure under local anesthesia. With each aspiration, a maximum of 3—5 ml of marrow could be tapped from the iliac crest before being diluted with blood. The dilution effect was based on a thin consistency of blood, ease of aspiration and patients not experiencing the pain of suction. In this study, a maximum of 15 ml of marrow could be injected into and about the fracture site as compared to 150 ml in Connolly’s study.3

Percutaneous bone marrow grafting is a safe procedure, as we encountered no infection at either the donor or recipient sites. However, patients did experience the marrow suction pain, but they all tolerated the procedure.

In this study we found that percutaneous bone marrow grafting was effective in inducing bone healing in established tibial non-union, as only 25% of our patients who were on the waiting list for open bone grafting needed this procedure.

Although our study cohort was a mixture of atrophic and hypertrophic types of non-union, we could not find a significant difference between the two groups. However, we acknowledge the possibility of committing a type II error due to the small number of patients in this study.

We recognize the limitations of our study, the number of patients is small and there is no control group. Furthermore, apart from plain radiographs we did not use sophisticated investigations for diagnosing non-union or establishing union. Non-union is best established by multiplanar CT scans, but this is not radiation free and repeating CT scans would prove expensive. We used clinical and radiological criteria in addition to patient’s confidence to pain free weight bearing as a parameter to solid union.

We would like to highlight percutaneous bone marrow grafting as a limited invasive technique which could be applied under local anaesthesia, is a simple, safe, inexpensive and effective method of treating tibial non-union. This makes it worth exploring before embarking on more extensive open surgery.

We highly recommend this technique for those patients with tibial non-union and minimal deformity.

Acknowledgements

No financial support was received for this study.

References