CASE REPORT

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Percutaneous injection of platelet-rich plasma to treat atrophic nonunion after internal fixation of ulnar fracture: a case report

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ABSTRACT

Non-union is a serious postoperative complication of fracture. Early detection and intervention can avoid revision surgery. Platelet-rich plasma releases many active tissue factors and has potential to promote fracture healing. Percutaneous injection of platelet-rich plasma at the fracture site may avoid surgical treatment when non-union occurs. We present a case of atrophic non-union of an ulna fracture treated conservatively with percutaneous injection of platelet-rich plasma.

Keywords: Platelet-rich plasma, PRP, ulna fracture, non-unions, atrophic non-union

Abbreviations:
PRP: platelet-rich plasma
ORIF: open reduction and internal fixation
PDGF: platelet-derived growth factor
TGF-β: transforming growth factor-β
MRI: magnetic resonance imaging

BACKGROUND

Non-union of an isolated ulnar shaft fracture is rare, due in part to the widespread use of modern plate-and-screw techniques.[1] However, persistent non-union of fractures after open reduction and internal fixation (ORIF) presents a significant challenge. Typically, non-union fractures are classified as either atrophic or hypertrophic. Atrophic non-union is further characterized as either acellular or oligocellular; such fractures are considered biologically inert.[2,3] The general

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approach to treating atrophic non-union is to improve the biological environment. Autologous bone grafting is often recommended due to its ability to promote bone formation; however, limited availability of source material and donor site morbidity severely limit its application.

Platelet-rich plasma (PRP) is a highly concentrated serum fraction extracted from whole blood.[4] PRP is used widely in a number of surgical fields due to the minimally invasive nature of plasma collection and its ability to accelerate wound healing, as shown in animal and clinical studies.[5,6] These effects are mediated in part by the numerous growth factors present in PRP, including platelet-derived growth factor (PDGF), transforming growth factor beta (TGF-β), and epidermal growth factor (EGF), all of which play important roles in bone healing.[7]

Here, we present a 12-year-old boy with atrophic non-union of the ulnar shaft more than 6 months after ORIF. In this case, direct injection of PRP into the affected area was used as the treatment for non-union of the ulna fracture, with satisfactory results.

CASE PRESENTATION

A 12-year-old boy presented to our hospital with acute right forearm pain and swelling due to an injury sustained while practicing taekwondo, which had persisted for at least 8 hours. Initial X-rays revealed a fracture of the ulnar shaft (Fig. 1A). Because he had a history of pituitary tumors and his height was 180 cm, we performed treatment of open reduction and internal fixation using a 3.5-mm locking recon plate (Smith & Nephew, USA). (Fig. 1B). Antibiotic prophylaxis with cefuroxime (1.5 g) was initiated 24 hours after surgery. The patient was discharged 3 days later, and we asked him to return monthly after surgery; however, regular radiographic examinations were not performed.

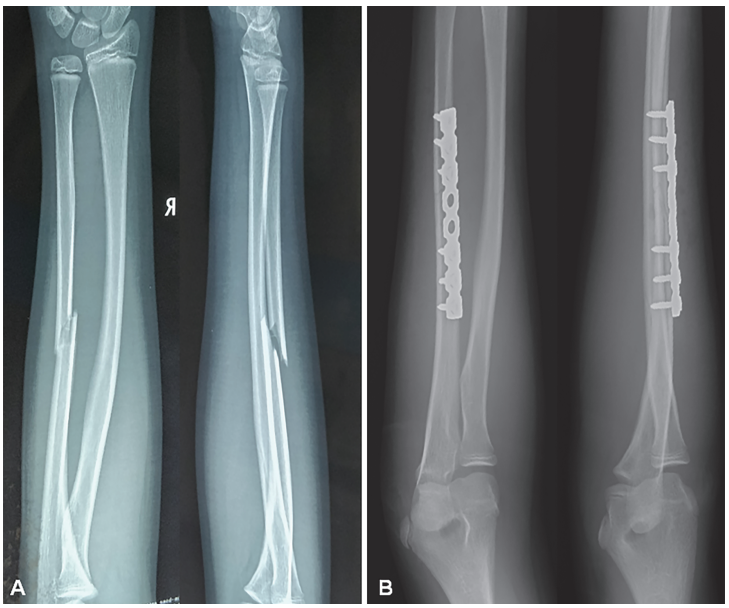

Fig. 1 Images before and after external fixation of fracture

Fig. 1A: The anteroposterior film and lateral film of forearm showed the oblique fracture of the right shaft ulna.

Fig. 1B: One day after open reduction and internal fixation (ORIF), the radiographs showed anatomic reduction of the ulna shaft fracture.

Six months after surgery, the patient underwent a forearm X-ray at the local hospital due to persistent weakness in the affected forearm. Radiologic images revealed no signs of healing of the ulna (Fig. 2), so the patient was referred to our hospital for further care. Upon physical examination, no significant tenderness was observed near the fracture end, and the function of the right forearm was similar to that of the left. Subsequent routine blood tests including routine blood counts, C-reactive protein, erythrocyte sedimentation rate, procalcitonin, and bone metabolism examination did not show any outliers. The patient underwent enhanced magnetic resonance imaging of the right forearm to rule out bone infection. The images showed that the soft tissue boundaries were clear, and there was no obvious abscess at the fracture end. The patient had a history of epilepsy, and he was referred to a neurologist. The examination by the neurologist and head magnetic resonance imaging revealed no sequelae of non-union. Based on these findings, we ruled out an infection. Finally, atrophic ulna non-union was diagnosed. Because the patient had been playing jazz drums three times per week (1 hour per playing session) after surgery, we suspected that the non-union was related to the patient's overuse of the affected limb.

Following ethics approval by the hospital review board, the patient was treated by PRP injection. The PRP fraction was prepared by Beijing Hanbaihan Medical Devices using standard methods. Briefly, 50 mL of whole blood was drawn from the antecubital fossa and then transferred into five PRP tubes. The peripheral blood was mixed with a separating gel and centrifuged (3,500 RPM; 1,500 × g) at room temperature using a CMM7 centrifuge. After centrifugation, red blood cells (RBCs) were separated from the cell concentrate in the plasma. The platelet-rich

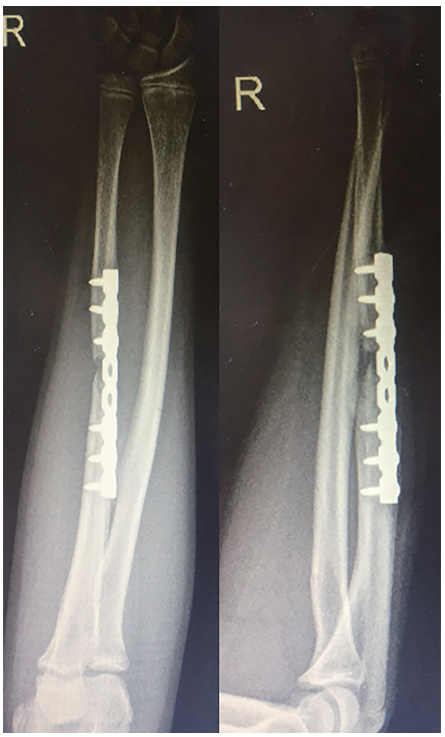

Fig. 2 The image of ulna nonunion
6 months after surgery, the anteroposterior film and lateral film of the forearm showed the atrophic nonunion of the right ulna shaft fracture, obvious bone resorption could be seen at the fracture end.

fraction was located between the separating gel and the plasma, with the RBCs pelleted below the gel (Fig. 3). Following separation, the PRP fraction was mixed by careful inversion. Then, a 10-mL syringe was used to draw and collect approximately 8 mL of PRP; 10% calcium gluconate was added to activate the PRP.

The injection steps were as follows: the patient was placed in the supine position with the right arm straight and the area cleaned aseptically. The fracture site was located by C-arm fluoroscopy (anteroposterior and lateral). Following treatment with local anesthesia (lidocaine), 2 mL PRP was injected into the lesion using an 18G (7 cm) needle within 2 min under fluoroscopy (Fig. 4). After the fracture end had been accurately positioned under the C-arm, PRP was injected around the fracture end; there was little resistance during the injection.

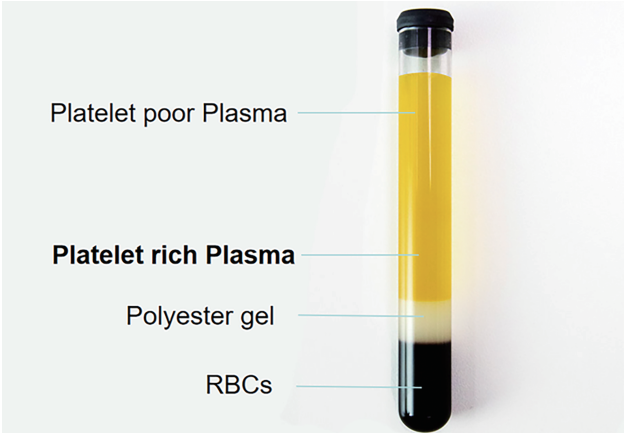

Fig. 3 PRP extracted pattern diagram
Anticoagulated blood after centrifugation is divided into 3 layers: plasma (including platelet poor and rich plasma), polyester gel and red blood cells (RBCs).

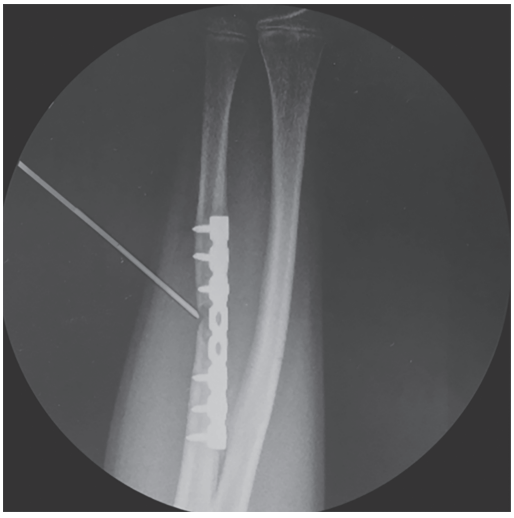

Fig. 4 X-ray image during PRP injection
Platelet-rich plasma was percutaneously injected into the fracture site under fluoroscope.

Following treatment, a plaster forearm splint was fixed for 4 weeks. The patient attended regular follow-up visits to assess fracture healing and evaluate any potential symptoms (Fig. 5). After 18 months of follow-up, the non-union healed completely and the limb strength returned to normal (Fig. 6A). At the 2-year follow-up, the plate was removed (Fig. 6B).

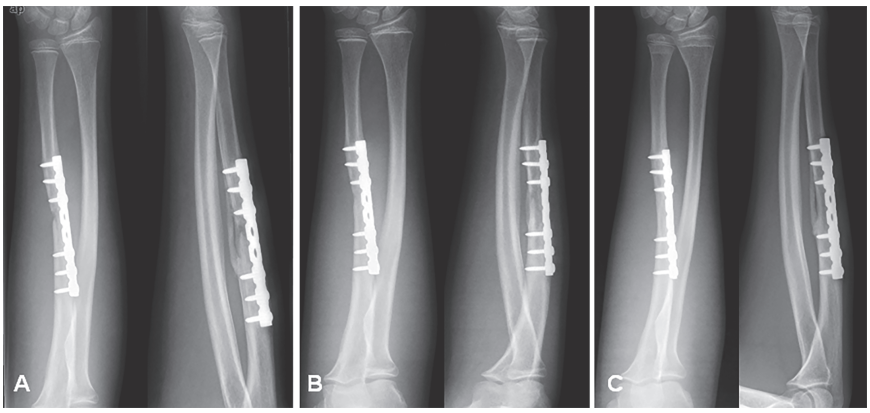

Fig. 5 Follow-up images after PRP injection

Fig.5A: 6 weeks after the injection of Platelet-rich plasma, a bone bridge growed around the fracture end.

Fig.5B: 12 weeks after the injection of Platelet-rich plasma, the fracture end was connected by callus.

Fig.5C: 15 months follow-up after the injection of Platelet-rich plasma, there was obvious osseous collection in the ulna fracture site.

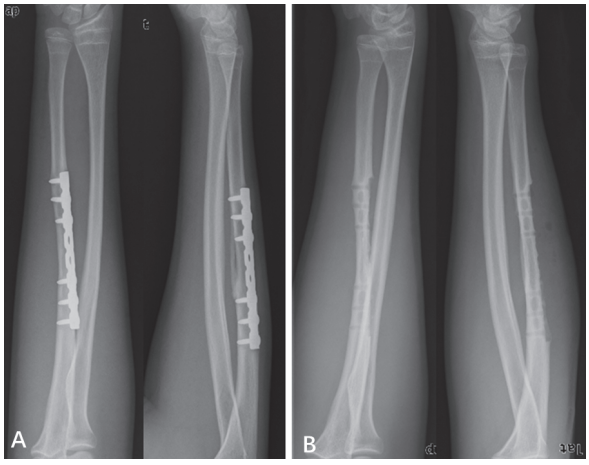

Fig. 6 Images after fracture healing and removal of internal fixation

Fig.6A: At 18 months follow-up, the recanalization of the medullary cavity and the firm cortical bone connection at the fracture site which demonstrate the complete union and healing of the ulna.

Fig.6B: At 2 years follow up, the patient removed the internal fixation and the fracture end healed well.

DISCUSSION

Ulnar shaft fractures are typically high-energy injuries that require ORIF for proper healing. Modern plate-and-screw fixation has dramatically reduced the incidence of complications; however, non-union remains a significant concern for forearm fractures, with a reported incidence of 2–10%.[8] Full resolution of ulnar injuries is important for long-term function, with non-union of the ulna shaft shown to directly affect wrist and elbow function if not addressed properly.[9-12]

Non-union refers to a failure to restore function and continuity with the adjacent bone after fracture.[13] Traditionally, if a fracture does not heal within 6–8 months, it is considered as non-union.[14] Non-union is generally classified as hypertrophic or atrophic based on a combination of radiological and histological criteria. Hypertrophic non-union is often caused by unstable fracture ends. Atrophic bone non-union is mainly related to vascular injury and excessive periosteal dissection during surgery; patients with premature or excessive activity can also develop atrophic bone non-union.[2] Atrophic non-union is typically regarded as non-viable, and is characterized by less callus and atrophy at the fracture end.[2] Atrophic non-union exhibits worse overall healing than hypertrophic non-union, and histological analyses can be used for further classification as the acellular or oligocellular subtype.[2,3]

Ulna non-union is typically atrophic in nature, with minimal biological activity. Restoration of biological activity remains a primary goal of any treatment, although the best way to achieve this remains unclear.[11] Common treatments include autogenous or vascularized bone graft, and bone marrow injection[11]; however, these approaches come with significant risks, including infection, malunion, non-union, nerve injury, and limited function. The risks associated with reoperation and the uncertainty of curative outcomes has led many clinicians to explore safer and potentially more effective treatments for non-union. Growth factors and bone morphogenetic proteins have garnered significant attention in recent few decades: bone morphogenetic proteins have been shown to play a key role in bone formation, development, and repair.[15] While bone morphogenetic proteins have shown promise in animal experiments, their potential applicability to human cases of non-union remains limited due to the significant risk of heterotopic ossification and high production costs.[15,16]

PRP is a concentrated fraction of platelets, cytokines, and growth factors derived from an individual's own anticoagulated whole blood. By removing RBCs and leukocytes, and concentrating the remaining fraction, platelets can be induced to release significant amounts of PDGF and TGF-β.[4,17] Studies have shown that PRP might augment recruitment of osteoblast progenitors to sites expected to experience delayed healing or non-union. In this capacity, PRP was utilized to treat a poorly healing skeletal lesion.[7] PRP represents a promising option for treating bone defects, with no significant side effects reported to date.[18]

A recent study by Guzel et al[6] examined the use of PRP for the treatment of femoral shaft fractures in rats. A total of 70 female rats were divided into three groups: Group I (no PRP, n = 30), Group II (PRP added, n = 30), and Group III (control, n = 10). Histological observations at 4 and 9 weeks after surgery revealed significantly better healing in Group II versus Group I rats. These results demonstrated that PRP can significantly accelerate the histological union of fractures. Similarly, Memeo et al[5] reported a case series of seven young patients with forearm fracture non-union treated by intramedullary nailing and PRP. All patients were shown to have achieved a full recovery based on radiologic assessments, with an average recovery time of 23 weeks. These results demonstrated that intramedullary nailing combined with PRP treatment was an effective alternative to autologous bone graft.

The case described here was of atrophic non-union of an ulna fracture, and the internal fixation was not loosened. After ruling out the possibility of local infection, PRP injection was

performed. Although current evidence does not support routine use of PRP in the treatment of fracture non-unions,[19] we believe that this approach may be useful for promoting fracture healing. This minimally invasive treatment has an excellent safety profile, is less time-consuming than alternative therapies, and can be performed under local anesthesia, thereby improving patient compliance. This study provides a model for treatment of ulna fracture non-union by percutaneous PRP injection, which may reduce the need for additional surgeries. To the best of our knowledge, this is the first reported case of atrophic non-union of ulna fracture after ORIF resolved by percutaneous injection of PRP.

However, PRP for the treatment of bone non-union remains controversial. Malhotra et al[20] demonstrated that PRP can only promote fracture healing when used in conjunction with osteoconductive scaffolds; we agree with that approach. In our case, the ulna fracture was fixed with a locking plate. X-rays showed atrophic non-union 6 months after surgery. We presume that the local area was stable, because non-union caused by instability is generally hypertrophic. Thus, we chose percutaneous injection of PRP alone. A case report is insufficient to confirm the effectiveness of PRP alone in fracture healing. Multi-sample or multi-center studies are needed to confirm the effectiveness of PRP injection in the treatment of non-union.

In summary, atrophic ulnar non-union is characterized by decreased biological activity at the fracture site. Injection of PRP is effective for delivering cytokines and other growth factors directly to the affected area, thereby helping to reactivate the healing process. The use of PRP is likely to increase in the future as its use in the treatment of non-union gains recognition, despite the lack of evidence supporting its efficacy. Here, we showed that PRP is a safe and effective method for stimulating fracture repair, and may represent a new option for the treatment of non-union.

FUNDING

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ETHICAL APPROVAL

This article does not contain any studies with human participants or animals performed by any of the authors.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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