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A new way to treat forearm post-traumatic non-union in young patients with intramedullary nailing and platelet-rich plasma

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ABSTRACT

Introduction: Non-union rate in forearm fractures is generally less than 2% when a proper technique is used; this rate increases when ulnar lesions are involved.
Patients and methods: We present a case series of seven young patients whose average age was 14 years (range 11–19 years) at the time of surgery and who presented with a forearm post-traumatic non-union that was previously treated in different ways (three isolated ulnar non-union, two isolated radial non-union and two combined). Average follow-up was 34 months (range 9–72 months).

Surgical treatment began with the removal of the previous synthesis and with curettage of the non-union area. The Acumed ulnar rod, Acumed radial rod and Thalon elastic nail (all of them are unreamed and locked nails) together with autologous platelet-rich plasma (PRP) obtained with the Biomet System (concentration of 158.2×10^4 platelets/μL) were chosen to treat the patients.

X-rays and clinical controls were conducted every 30 days until recovery.
Results: All patients recovered: average recovery was 23 weeks from operation (range 16–36 weeks) and nails were removed 3 months after complete healing. Six patients had excellent results and one patient had a good result (Patient 2, forearm pronosupination 60–0–40 degrees).
Discussion: The purpose of the case series was to establish a better way of treatment and to find a technique that could avoid the use of bone grafts, because obtaining autologous bone requires a further surgical procedure that can be really invasive depending on the amount of bone needed.
Conclusion: All patients in the study showed complete recovery, with excellent clinical outcomes. Although there were only seven patients in this case series, and there is a need to analyse more patients, this study showed that the use of a specific locking nail system can provide proper stability to ulnar or radial atrophic non-union despite rotational forces, and when combined with autologous growth factors (PRP) is sufficient to promote bone healing in young patients without the necessity to take autologous bone grafts.

Introduction

Impaired healing continues to be one of the most severe complications of fractures despite the intrinsic regenerative and reparative capacity of bones, the ongoing progress in their treatment and increasing understanding of fracture repair processes. Approximately 5–10% of fractures sustained in the United States are associated with delayed healing or non-union [1].

Non-union is one of the most dangerous complications of forearm fractures: it occurs as a result of anatomical causes, such as the relative thickness of cortical bones or to the smallness of the medullary and the precarious ulnar vascularisation [1–4], or because of mechanical reasons.

Several strategies have been devised and investigated on this subject and it has been concluded that the use of a combined approach is likely to produce the best clinical outcome [5]. Traditionally, the problems that are related to fracture-healing have been treated with operative intervention, which often involves the use of an autologous bone graft [6,7]. However, bone graft-harvesting procedures are associated with a morbidity rate of 10–30%, and only limited amounts of bone are available [8]. Alternative strategies designed to enhance healing of acute fractures and to improve treatment of delayed unions and non-unions are required.

The rate of non-union in forearm fractures is generally less than 2% when proper technique is used in compliant patients [9], but the rate of non-union after ulnar lesions is considerably higher [10,11]. Biomechanical investigations [12] showed that the ulna is mainly

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responsible for stabilising the forearm with respect to axial and torsional bending. Biomechanical features of intramedullary implants are important for isolated or combined forearm fractures and even more so in non-unions, particularly for stability towards torsional and compressive forces.

Osteosynthesis treatment of the ulnar or the radial non-union usually comprises the use of a dynamic compression plate or an intramedullary nail and an autologous cancellous bone graft [6,13–15]. The novelty of our treatment is the combination of a particular unreamed locked intramedullary nail (the Acumed ulnar rod, Acumed radial rod or Thalon elastic nail) associated with the use of autologous platelet-rich plasma (PRP). The use of a locked unreamed nail ensures rotational stability [16,17] and PRP enhances the healing of non-union thereby circumventing the need for autologous bone graft. PRP preparation simply requires a sample of blood instead of more invasive procedures utilised for bone-grafting. Growth factors regulate cell behaviour and therefore are excellent candidates to serve as agents in these adverse circumstances as they can ensure or accelerate the bone repair process. Platelets produce multiple growth factors. PRP is an autologous source of platelets and is obtained by sequestering and concentrating platelets by gradient density centrifugation.

PRP is a combination of seven native growth factors within a normal clot as the carrier. The clot comprises fibrin, fibronectin and vitronectin, which are cell adhesion molecules, and the growth factors are platelet-derived growth factor αα (PDGF-αα), PDGF-ββ, PDGF-αβ, transforming growth factor beta1 (TGF-β1), TGF-β2, vascular endothelial growth factor (VEGF) and epithelial growth factor (EGF) [18,19]. Platelets and their products recruit, and lead to the proliferation of, mesenchymal progenitor cells and osteoblasts. A concentration of platelets at the fracture site may lead to the proliferation of osteoblasts in the area and may increase the rate of bone healing. Growth factors have been widely proven to act as stimulators for the proliferation of osteoblasts *in vitro* and for the healing of bones *in vivo* and they are now considered to be useful in healing processes if applied correctly to the injury site [20–22].

Patients and methods

We present a case series of seven young patients whose average age was 14 years (range 11–19 years) at the time of surgery and who presented with a forearm post-traumatic non-union that was previously treated in different ways (three isolated ulnar non-union, two isolated radial non-union and two combined) (Figs. 1–5). Average follow up was 34 months (range 9–72 months) (Table 1). Preoperative X-rays showed delayed atrophic non-union (Figs. 1–5) and clinical examination proved a lack of mobility and pain in all patients.

Surgical treatment began with the removal of the previous synthesis; patients who had been treated previously with external fixation had to wait 15 days before our definitive treatment to reduce the risk of contamination (Patient 2). After the removal of the previous synthesis, the fibrous tissue of the non-union was completely removed with curettes resulting in a bed of healthy bone.

Fig. 1. Patient 1, ulnar isolated non-union as a consequence of a previous treatment with plate and screws.

Acumed ulnar rod, Acumed radial rod and Thalon elastic nail were chosen to treat the patients; all of them are unreamed and

Table 1
Summary of patients included in the study.

Patient	Age (years)	Gender	Type of non-union	Type of nail	Follow-up (months)
1	18	m	Ulnar	Acumed ulnar rod 230 mm length 3 mm diameter	60
2	19	f	Ulnar	Acumed ulnar rod 210 mm length 3 mm diameter	66
3	14	m	Radial + Ulnar	Acumed ulnar rod 230 mm length 3 mm diameter(ulnar), Acumed radial rod 190 mm length 3 mm diameter(radial)	72
4	13	m	Radial + Ulnar	Thalon 210 mm length 3 mm diameter(radial) + Kirschen wire (ulnar)	9
5	11	m	Radial	Thalon 165 mm length 3 mm diameter(radial)	10
6	11	m	Radial	Thalon 210 mm length 3 mm diameter(radial)	12
7	17	m	Radial + Ulnar	Acumed ulnar rod 250 mm length 3 mm diameter(ulnar), Acumed radial rod 210 mm length 3 mm diameter(radial)	14