Efficacy of Platelet Gel in Reconstructive Bone Surgery

MASSIMO FRANCHINI, MD*; PAOLO DUPPLICATO, MD†; ISABELLA FERRO, SCD*; MARZIA DE GIRONCOLI, MD*; ROBERTO ALDEGHERI, MD‡

abstract

Autologous platelet concentrate and cryoprecipitate, mixed to obtain a gel, have been successful in various operations, primarily oral and maxillofacial surgery. This study assessed the use of platelet gel in 19 patients undergoing 22 reconstructive bone surgical procedures. After a median follow-up of 12.9 months, improved osteoblastic reaction and reconstruction of physiologic bone structure was observed in all patients with no adverse reactions. These findings confirm the osteoinductive property of platelet gel in reconstructive bone surgery.

Nontransfusion therapeutic use of autologous blood components has been steadily increasing in the past several years and has been used for several applications with successful clinical outcomes.[1,2] The first blood component used was fibrin glue, which proved successful as a topical hemostat, adhesive, and reparative agent, primarily in oral and maxillofacial surgery.[3-5]

A further improvement in reconstructive bone surgery recently was achieved with the topical use of autologous concentrated and activated platelets as a gel.[6,7] Platelet gel, rich in growth factors released from platelet alpha granules (platelet-derived growth factor, transforming growth factor β, and insulin-like growth factor), is a powerful agent that stimulates duplication, activation and growth of mesenchymal cells (mainly osteoblasts, fibroblasts, and endothelial cells) and, finally, tissue regeneration.[8]

This study reports the use of platelet gel in 19 patients who underwent 22 reconstructive bone surgical procedures.

MATERIALS AND METHODS

Between October 2001 and July 2003, 19 patients (8 males and 11 females) underwent 22 reconstructive bone surgical procedures with the use of platelet gel. Median patient age was 36.3 years (range: 15-69 years).

Indications for surgery are listed in Table 1. In all cases, the procedures were necessary as reconstruction surgery or as treatment for impaired fracture repair.

Platelet gel was used in association with hydroxyapatite. To obtain the platelet gel, one unit of whole blood (450 mL) was drawn from the patient the day before the operation.

The blood was centrifuged at 2630 rpm for 4 minutes to separate platelet-rich plasma from erythrocytes, which were reinfused into the patients. The platelet-rich plasma was then centrifuged at 3870 rpm for 6 minutes to obtain platelet concentrate and platelet-poor plasma.

The platelet concentrate was stored at 22°C, whereas the platelet-poor plasma was frozen at −80°C and then thawed slowly at +4°C overnight. The supernatant plasma was removed, and the cryoprecipitate was frozen again at -80°C within 1 hour.

The next day, in the operating room, the platelet concentrate and the thawed cryoprecipitate were placed in two sterile cups in the surgical field, and 10 mL of platelet concentrate, 4 mL of cryoprecipitate, 2 mL of 10% calcium chloride, 2 mL of batroxobin and 2 mL of air were aspirated in succession into a syringe and rocked. The contents were then expelled into a sterile cup and mixed with hydroxyapatite, thus creating an insoluble autologous platelet gel that was applied as needed.

RESULTS

Data regarding platelet concentrate and

*From the *Transfusion Service, Hospital of Verona, Verona; the †Orthopedic Clinic, University of Verona, Verona; and the ‡Orthopedic Clinic, University of Padova, Padova, Italy.*

Reprint requests: Massimo Franchini, MD, Servizio di Immunoematologia e Trasfusione, Ospedale Policlinico, Piazzale L. Scuro, 10, 37134 Verona, Italy.

TABLE 1

Indications for Reconstructive Bone Surgery Among the Study Population

Indication	No. Procedures
Osteomyelitis	
Femur	1
Tibia	2
Fibrous dysplasia	
Tibia	1
Fracture	
Tibia	5
Femur	1
Pseudoarthrosis	
Tibia	2
Ulna	1
Total hip arthroplasty with acetabular reconstruction for acetabular dysplasia	3
Bilateral lower-extremity lengthening	
Tibia (for congenital short tibiae)	1
Humerus (for achondroplasia)	1
Bilateral hip arthroplasty with acetabular reconstruction for rheumatoid arthritis	1
Revision of hip prosthesis	3

cryoprecipitate volumes; precollection platelet, leukocyte, and fibrinogen levels; platelet and leukocyte counts of the platelet concentrate; and fibrinogen levels of the cryoprecipitate are listed in Table 2. The mean platelet concentration in the platelet concentrate was $3.4 \times 10^6/\mu L$ with a platelet recovery of 90.9%.

To assess the osteoinductive effect of the platelet gel, radiographic and clinical examinations were performed every 3 months. After a median follow-up of 12.9 months (range: 9-16 months), radiographs showed improved osteoblastic reaction and reconstruction of physiologic bone structure in all patients. In particular, progressive incorporation of hydroxyapatite into the surrounding bone was observed, as documented by the progressive dissolution in its granular weave and the gradual decrease in radio-opacity, which became similar to that of the surrounding bone (Figures 1-3).

The clinical results were good, with no

TABLE 2

Characteristics of the Platelet Gel

Characteristics	Mean	SD	Range
Platelet concentrate volume (mL)	29.1	7.9	22-50
Cryoprecipitate volume (mL)	22.3	4.0	18-32
Patient precollection values			
Platelet count ($\times 10^3/\mu L$)	244.8	56.9	154-339
Leukocyte count ($\times 10^9/L$)	7.2	1.7	4.7-9.7
Fibrinogen level (mg/dL)	354.6	123.4	235-572
Platelet concentrate			
Platelet count ($\times 10^6/\mu L$)	3.4	1.2	1.5-6.0
Leukocyte count ($\times 10^6/\mu L$)	9.5	5.0	1.2-16.0
Cryoprecipitate			
Fibrinogen levels (mg/dL)	647.8	215.9	259-1080

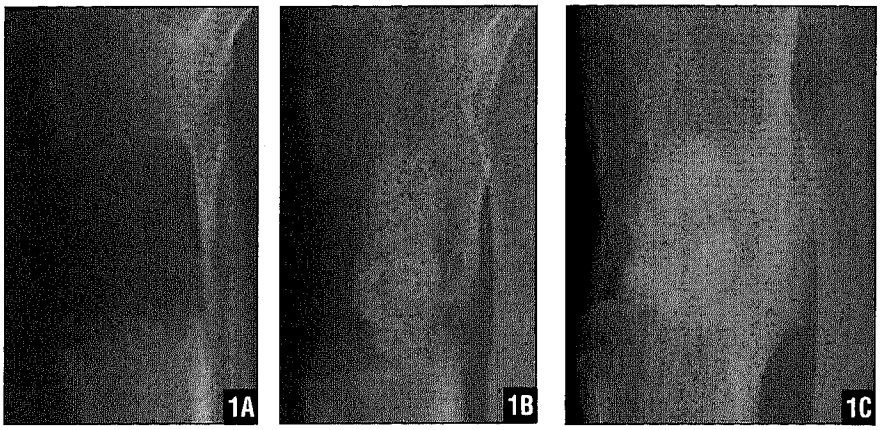

Figure 1: Radiographs of the left tibia in a 25-year-old patient who underwent bilateral tibial lengthening with an external fixator. At the end of the lengthening, given the inadequate distractional osteogenesis, platelet gel and hydroxyapatite were inserted (A) while maintaining the fixator in situ (B). Six months postoperatively, reconstruction of the lengthened bone, initial cortical formation of the graft, and disappearance of the granular weave of the hydroxyapatite were evident (C).

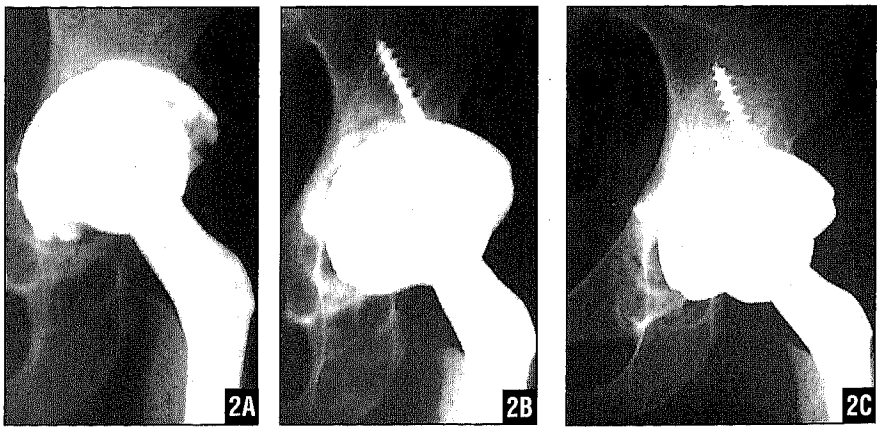

Figure 2: Radiographs of a 28-year-old woman who underwent a left total hip replacement because of severe congenital femoral deformation. Twelve months postoperatively, there was an aseptic mobilization of the prosthesis, with periprosthetic reabsorption of the acetabulum and interruption of the quadrilateral lamina (A). A new, uncemented acetabular cup was positioned and fixed with screws, with platelet gel and hydroxyapatite graft at its base. Three (B) and nine (C) months postoperatively, reconstruction of the base of the cup and excellent osteointegration were evident.

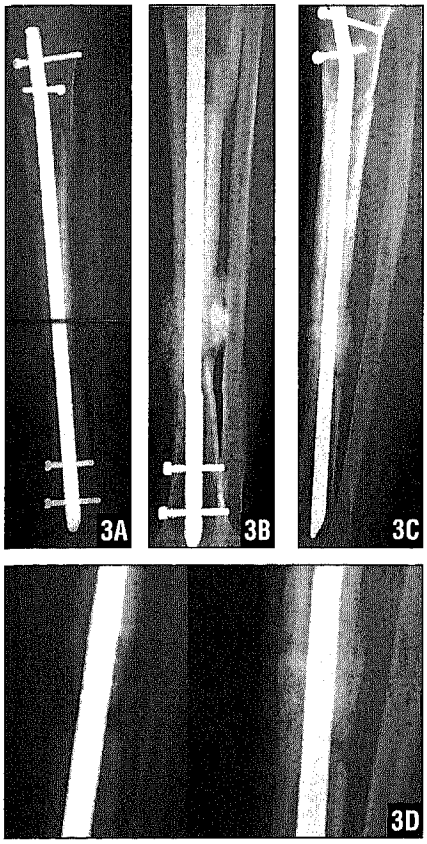

Figure 3: Radiographs of a 49-year-old patient with a compound double fracture of the tibia with loss of bone who was treated urgently with an external fixator and then with intramedullary nailing 1 month later. Given the persistent lack of bone and delayed consolidation in the distal fracture (A), platelet gel and hydroxyapatite were inserted into the site (B). The radiograph obtained after 6 months (C) and the comparison image (D) showed filling of the lost substance, the lack of areas of resorption, disappearance of the granular weave, and osteointegration.

peri- or postoperative surgical complications and complete osteointegration of the graft. By their 3-month follow-up examination, 17 of 17 patients who underwent 20 lower limb procedures were walking autonomously and had recovered full load bearing on the operated limb. In 8 of 8 cases, an external fixator had been removed. None of the patients reported experiencing pain.

What is already known on this topic

- This is the first study reported in the literature on the use of platelet gel in reconstructive bone surgery.

What this article adds

- This study documents the efficacy of platelet gel in stimulating bone regeneration following reconstructive surgery.

DISCUSSION

Although this study, the first reported in the literature on this topic, describes a small series of patients, the results demonstrate the efficacy of platelet gel derived from platelet-rich plasma and cryoprecipitate in stimulating bone regeneration following reconstructive surgery. In the future, blood bankers will be asked increasingly frequently for this product. In fact, it is easy to foresee the routine use of platelet gel, in combination with biomaterials (eg, hydroxyapatite) or with bone from a tissue bank, in such surgical procedures during the next few years.

However, long-term follow-up trials on larger populations of patients undergoing reconstructive bone surgery, including histologic proof of the osteoinductive properties of platelet gel, are needed to confirm the safety and efficacy of such a method. ◙

REFERENCES

1. Tarroni G, Tessarin G, De Silvestro L, et al. Local therapy with platelet-derived growth factors for chronic diabetic ulcers in haemodialysis patients. *G Ital Nefrol.* 2002; 19:630-633.
2. Withman DH, Berry RL, Green DM. Platelet gel: an autologous alternative to fibrin glue with applications in oral and maxillofacial surgery. *J Oral Maxillofac Surg.* 1997; 55:1294-1299.
3. Tayapongsak P, O'Brien DA, Monteiro CB, Arceo-Diaz LY. Autologous fibrin adhesive in mandibular reconstruction with particulate cancellous bone marrow. *J Oral Maxillofac Surg.* 1994; 52:161-165.
4. Dresdale A, Bowman FO, Malm JR, et al. Hemostatic effectiveness of fibrin glue derived from single-donor fresh frozen plasma. *Ann Thorac Surg.* 1985; 40:385-387.
5. Martinowitz U, Spotnitz WD. Fibrin tissue adhesives. *Thromb Haemost.* 1997; 78: 661-666.
6. Marx RE, Carlson ER, Eichstaedt RM, Schimmele SR, Strauss JE, Georgeff KR. Platelet-rich plasma. Growth factor enhancement for bone grafts. *J Oral Maxillofac Surg.* 1998; 85:638-646.
7. Zimmerman R, Jakubietz R, Jakubietz M. Different preparation methods to obtain platelet components as a source of growth factors for local application. *Transfusion.* 2001; 41:1217-1224.
8. Slater M, Patava J, Kingham K, Mason RS. Involvement of platelets in stimulating osteogenic activity. *J Orthop Res.* 1995; 13:655-663.