
Concentrated Autologous Adult Stem Cells vs. Autologous Iliac Crest Bone for Instrumented Fusion of the Lumbar Spine: Clinical and Laboratory Results for Two Consecutive Patients

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November 17, 2008

Background

When persistent pain and disability of the lumbar spine does not respond to non-surgical options (rest, oral and injectable pain meds, muscle relaxants, physical therapy, bracing and behavior change) and diagnostic & imaging tests show structural issues, a spinal fusion is often considered. Risk factors to healing, such as smoking, alcohol abuse, cirrhosis, obesity, diabetes and poor nutrition, also play an important role when considering spinal fusion.

Harvested Autologous Iliac Crest Bone Grafts (ICBG) remains the gold standard (because of its osteogenic properties) to augment spinal instrumentation and fusion. However, issues with ICBG include donor site morbidity (bleeding, infection, chronic pain) and limited availability (if previously harvested). As a result, there is a need for a safe and renewable source of osteogenic stem cells to supplement or potentially replace ICBG.

The iliac crest contains a large reservoir of progenitor cells that, if harvested in a minimally invasive procedure, in sufficient numbers and added to allograft bone, may obviate the need to harvest ICBG. Recent studies have shown that concentrating the nucleated cells in bone marrow, specifically stem cells, improves bone healing in tibial non-unions¹ and osteonecrosis of the femoral head², even when co-morbidities are present.

My current experience using allograft and autologous concentrated stem cells in lumbar spinal fusions is approaching 700 patients with positive results to date. This experience prompted me to pursue a prospective controlled pilot study. This Case Report Series reports on two patients at 12 month follow-up in a 25 patient IRB-approved randomized controlled study where ICBG was randomized to one side of a 1 to 3 level posterior lumbar fusion and the contralateral side received allograft bone augmented with 20 or 30 mL concentrated adult stem cells from 120 or 180 mL of bone marrow aspirated from the iliac crest.

Materials & Methods

Bone Marrow Aspirate (BMA) was aspirated from the posterior iliac crests using an 11 gauge 5 side-hole Jamshidi needle and a 60 mL syringe flushed with heparinized saline. Following a midline incision, the needle was directed at about 30° to the vertical and parallel to the plane of the crest and inserted to a depth of approximately 5 to 8 cm (Figure 1). Sixty mL of BMA was aspirated while rotating and slowly withdrawing the needle toward the cortex. This step was repeated on the contralateral ileum for a total of 120 or 180 mL of BMA. The BMA was then pooled into a blood bag containing Anticoagulant Citrate Dextrose Solution (ACD-A).



Fig.1



Fig.2

The BMA was then placed into the SmartPREP® Bone Marrow Concentrate (BMAC™, Harvest Technologies Corp., Plymouth, MA) system and concentrated in 15 minutes to a final volume of 20 or 30 mL. The BMAC was then combined with packed allograft cancellous bone chips (Spine Smith, Austin, TX) using the Graft Delivery Pack (GDP, Harvest Technologies Corp.) yielding two or three 10 mL surgeon constructed bone logs (Figure 2). The allograft logs were placed in the lateral gutter and interbody cages. The autograft bone was intentionally harvested from the opposite side of bone marrow aspiration, was then placed in the contralateral gutter and interbody cages. Using the standard technique for posterior lateral fusion, the bone graft was laid onto the decorticated transverse processes and lateral aspects of the facets, par interarticularis and onto the facets (Randomized left or right side; see CT's). Samples of BMA and BMAC were analyzed for Nucleated cells, Platelets, Mononuclear Cells, Flow Cytometry (CD34+) and Colony Forming Units (CFU-F) at The Center for Blood Research, Boston, MA. (Table 1)

Patient 1

47 YO male, diabetic, 2 PPD smoker (for 20 years; continued smoking throughout follow-up) with elevated blood pressure and Type 2 diabetes suffered a work related injury when a dump truck ran a stop sign and struck him. Pt presents with severe pain in lower back greater than left leg down to his heel with numbness and tingling into toes of left foot. Physical exam shows pain in the lumbosacral area and left buttock, limited forward flexion, negative straight leg raising, normal muscle strength and symmetric reflexes. Conservative measures had failed.

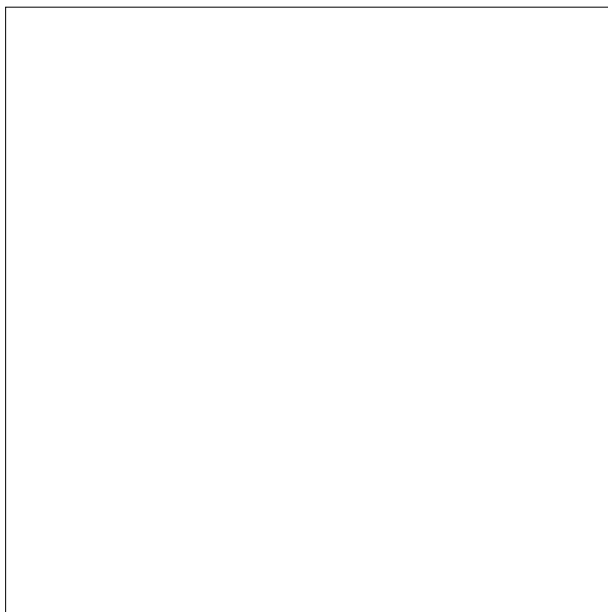
X-Rays and MRI scan showed degenerative changes at L4-L5 and L5-S1.

Operative Procedure

120 mL bone marrow (BMA) was aspirated and processed as described above. Pt underwent a 2 level decompression and fusion of L4-S1 with bilateral pedicle screws and posterior rod fixation. Patient was randomized to receive autograft in the right lateral gutter and concentrated autologous stem cells with allograft matrix in the left lateral gutter.

Post-Operative Results

At 1 year post-op, the Oswestry score had dropped from 21 pre-op to 16. He was working full time and continued smoking 2PPD. CT scan is shown. (Figure 3-5).



Patient 2

51 YO male, 1 PPD smoker with Type 2 diabetes, alcoholic cirrhosis, seizures and hypertension presented with low back and left leg pain. Physical exam showed reduced ROM back with no root tension or neurologic signs. He worked as an army supply tech and was considering retirement due to his back injury.

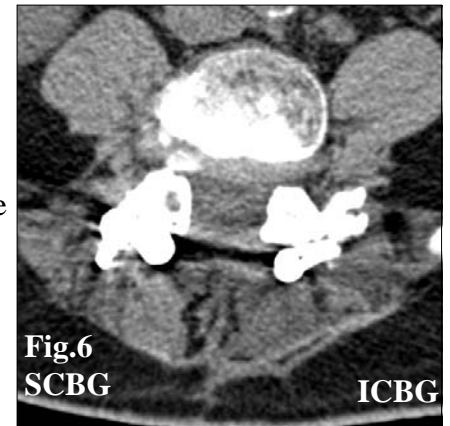
MRI showed three level DDD with facet arthropathy and foraminal stenosis.

Operative Procedure

180 ml of bone marrow was aspirated from the right iliac crest. Surgery consisted of L3-S1 decompression, lateral fusion, facet fusion and interbody cages at L3-L4 and L5-S1. Patient was randomized to receive autograft in the left lateral gutter and interbody cages and concentrated autologous stem cells with allograft matrix in the right lateral gutter and interbody cages.

Post-Operative Result

At 1 year post-op, the Oswestry score dropped from 21 pre-op to 2. He was working part time. CT scan is shown. (Figures 6-9).



Laboratory results are shown in Table 1 below. These data compare favorably with Hernigou³ who achieved bone healing when >1500 CFU-F/mL was achieved.

Table 1							
	BMAC Volume mL	Nucleated Cells x10 ⁹	Platelet x10 ⁹	Mononucleated Cells x10 ⁶	CD34 ⁺ Cells x10 ⁶	Colony Forming Units - F <i>Total Progenitor Cells Grafted</i>	Colony Forming Units - F <i>CFU-F/mL</i>
Pt#1	20	3.6	8.4	912	26.2	40300	2015
Pt#2	30	2.2	9.6	716	10.9	44764	1444



Conclusion

A grade of "fusion" requires less than 3° of angulation on lateral flexion and extension radiographs; no loss of fixation, peri-implant lucencies of the pedicle screw constructs, and evidence of trabecular bridging bone from the transverse process to transverse process on reconstructed CT scans on contiguous levels. These patients have been followed for 12 months to date at 3 month intervals. Radiograph imaging at each follow-up visit and a CT at 12 months read by a blinded radiologist shows stable instrumentation and progressive bone formation on both sides of the spine (autograft side and BMAC side).

Previous reports by Connolly¹, Gangji², Hernigou³ and others have shown that high concentrations of adult stem cells from iliac crest bone marrow can enhance the rate and amount of bone formation. Applying a point-of-care technology that quickly and easily concentrates bone marrow stem cells 3 to 6 times baseline makes practical the use of adult bone marrow stem cells in spinal fusion. In these first patients of 25, the clinical and laboratory results are encouraging. If the remaining study patients continue to reflect these first patients outcome, autologous adult stem cells concentrated from bone marrow harvested from the iliac crest may become a viable alternative to iliac crest bone grafting and its inherent associated morbidity.

1. Connolly, J. et al, Autologous Marrow Injection as a Substitute for Operative Grafting of Tibial Nonunions, *Clinical Orthopaedics and Related Research*. 263: 259-270; 1991.
2. Gangji, V. et al, Treatment of Osteonecrosis of the Femoral Head with Implantation of Autologous Bone-Marrow Cells. A Pilot Study. *The Journal of Bone and Joint Surgery*. 86:1153-1160, 2004.
3. Hernigou, P. et al, Percutaneous Autologous Bone-Marrow Grafting for Nonunions: Influences of the Number and Concentration of Progenitor Cells, *The Journal of Bone and Joint Surgery*. 87-A: 1430-1437; 2005.

