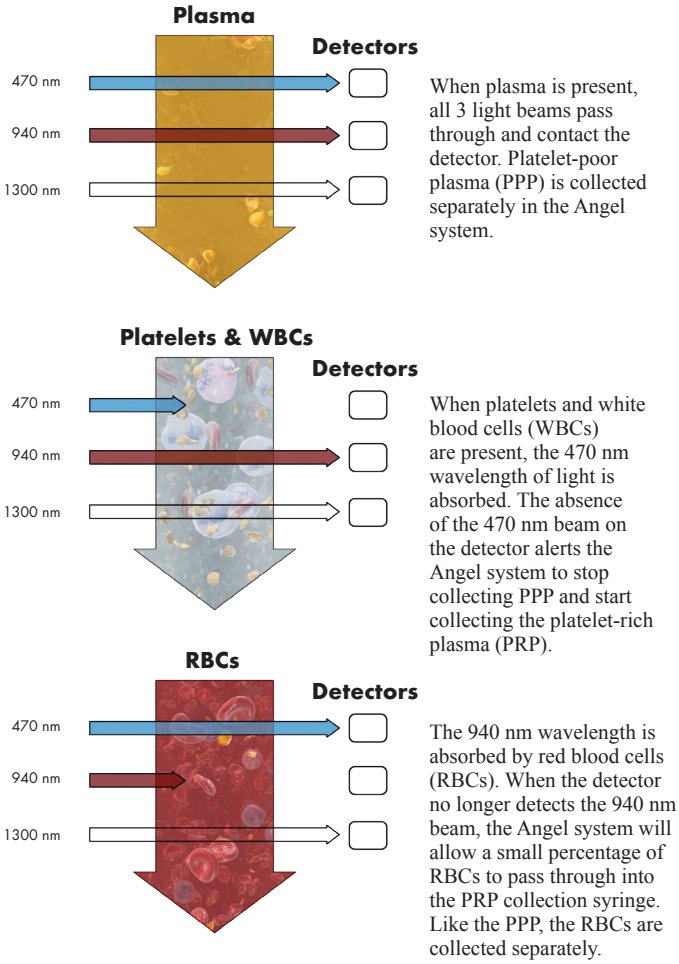
# Arthrex Angel® cPRP and Aspiration System

Arthrex Research and Development

## Purpose

The Arthrex Angel® system is an advanced platlet rich plasma processing system. The Angel system's 3-sensor technology (3ST) allows for customization of different autologous cellular products. The Angel system produces customized cellular product by using 3 specific wavelengths of light to more precisely separate cell types after centrifugation. **Figure 1** illustrates this process. Additionally, starting volumes (40 mL-180 mL), delivery volumes, and hematocrit (HCT) settings can all be customized using the Arthrex Angel system. By controlling the aforementioned variables, a clinician can tailor a specific cellular formulation for individual patients. The first section illustrates the cellular differences between equal volumes of whole blood and bone marrow aspirate (BMA). The second section illustrates how the different Angel HCT settings can affect concentrations in platelet-rich plasma (PRP) from BMA ($cPRP_{BMA}$). Also demonstrated is the effect of expanding the final $cPRP_{BMA}$ volume with autologous platelet-rich plasma (PRP).

**Figure 1:** Three wavelengths of light.




## Materials and Methods

Approximately 60 mL of heparinized human BMA from the iliac crest (bilateral aspiration) was obtained (Lonza Group). Nine donors were used with a mean age 33 ± 5 years (range, 26-41). After a control sample was aliquoted, the 60 mL BMA specimen was processed in the Angel system. Due to the limited BMA volume available, only one HCT setting was used on each donor. BMA was processed from 3 donors at each of the following Angel HCT settings: 7%, 10%, and 15%. After processing, aliquots of $cPRP_{BMA}$ and PPP were analyzed for specific cell concentrations: red blood cells (RBCs), white blood cells (WBCs), neutrophils (NEs), platelets (PLTs), total nucleated cells (TNCs), and hematopoetic progenitor cells (HPCs) using a BMA validated hematological analyzer (Sysmex XE-5000). For each HCT setting, cellular concentrations were measured on the raw output and the diluted 7 mL sample. The control BMA was also analyzed for the same cellular concentrations.

## Results

**Figure 2** depicts the different cellular layers after a sample of BMA has been centrifuged. **Table 1** illustrates the different cellular concentrations in BMA versus whole blood. **Table 2** shows the raw volume of $cPRP_{BMA}$ outputs for the different HCT settings and the Angel $cPRP_{BMA}$ ratios when compared to baseline BMA: RBC concentration of 7% HCT $cPRP_{BMA}$) / (RBC concentration of BMA). **Figures 3-8** illustrate the cellular concentrations in the BMA and Angel $cPRP_{BMA}$. Note that "7% HCT" denotes the $cPRP_{BMA}$ sample after processing 60 mL of BMA at the 7% HCT setting; "7% HCT 7 mL" denotes the BMC sample after processing 60 mL of BMA at the 7% HCT setting then expanding with PPP to achieve a final volume of 7 mL.

**Figure 2:** Centrifugal density gradient of bone marrow aspirate.

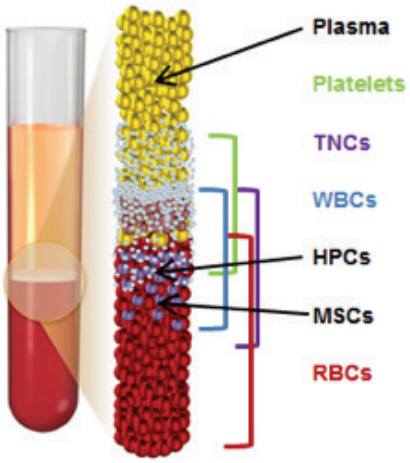


**Table 1:** Blood and BMA cellular concentrations

| (n=12) | WBC x(10^3/μL) | RBC(M/μL) | PLT x(10^3/μL) | NE x(10^3/μL) | LY x(10^3/μL) | MO x(10^3/μL) |
|---|---|---|---|---|---|---|
| Blood | 5.1 ± 0.8 | 4.3 ± 0.2 | 190.8 ± 44.3 | 2.8 ± 0.7 | 1.7 ± 0.6 | 0.5 ± 0.1 |
| BMA | 17.3 ± 7.0 | 4.1 ± 0.5 | 105.1 ± 32.0 | 7.5 ± 3.4 | 4.3 ± 2.7 | 1.0 ± 0.7 |
| Fold increase in BMA | 3.4 | 1.0 | 0.6 | 2.7 | 2.5 | 2.0 |

**Table 2:** Typical cellular ratios produced from BMA processed through the Arthrex Angel® cPRP and bone marrow processing system relative to baseline BMA concentration

| | N | Volume (mL) | WBC Ratio | RBC Ratio | NRBC Ratio | PLT Ratio | NE Ratio | LY Ratio | MO Ratio | TNC Ratio | HPC Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7% HCT | 3 | 1.5 ± 0.3 | 9.5 ± 1.8 | 0.2 ± 0.0 | 9.4 ± 1.0 | 9.2 ± 4.3 | 8.2 ± 2.5 | 10.6 ± 3.9 | 10.1 ± 3.2 | 9.5 ± 1.7 | 33.2 ± 12.6 |
| 10% HCT | 3 | 1.6 ± 0.1 | 14.6 ± 2.1 | 0.7 ± 0.2 | 12.7 ± 1.6 | 9.2 ± 3.2 | 14.5 ± 7.3 | 13.1 ± 3.6 | 15.8 ± 5.3 | 14.4 ± 1.9 | 38.2 ± 7.0 |
| 15% HCT | 3 | 2.1 ± 0.1 | 13.1 ± 2.9 | 0.9 ± 0.1 | 12.0 ± 2.6 | 7.2 ± 2.4 | 14.0 ± 3.7 | 8.2 ± 1.7 | 17.7 ± 4.7 | 13.0 ± 2.9 | 45.1 ± 20.5 |
| 7% HCT | 3 | 7.00 | 2.0 ± 0.4 | 0.1 ± 0.0 | 2.0 ± 0.2 | 2.3 ± 1.1 | 1.7 ± 0.5 | 2.2 ± 0.8 | 2.1 ± 0.7 | 2.0 ± 0.4 | 7.0 ± 2.7 |
| 10% HCT | 3 | 7.00 | 3.3 ± 0.5 | 0.2 ± 0.0 | 2.9 ± 0.4 | 2.3 ± 0.8 | 3.2 ± 1.6 | 2.9 ± 0.8 | 3.6 ± 1.2 | 3.2 ± 0.4 | 8.8 ± 1.6 |
| 15% HCT | 3 | 7.00 | 3.9 ± 0.9 | 0.3 ± 0.0 | 3.6 ± 0.8 | 2.4 ± 0.8 | 4.1 ± 1.1 | 2.4 ± 0.5 | 5.2 ± 1.4 | 3.9 ± 0.8 | 13.3 ± 6.0 |

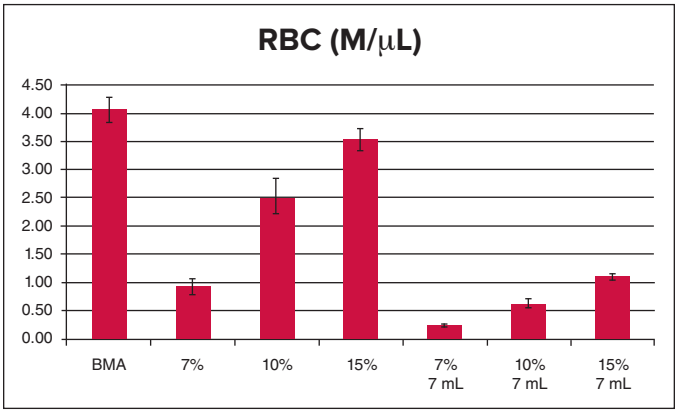



**Figure 3:** RBC concentration in BMA and Angel cPRP$_{BMA}$.

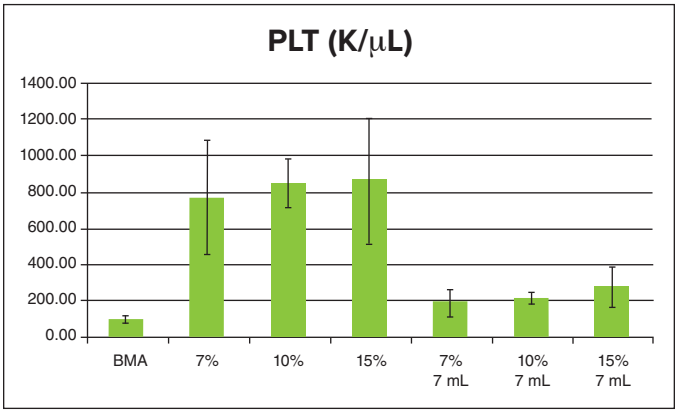



Figure 4: PLT concentration in BMA and Angel cPRP$_{BMA}$.

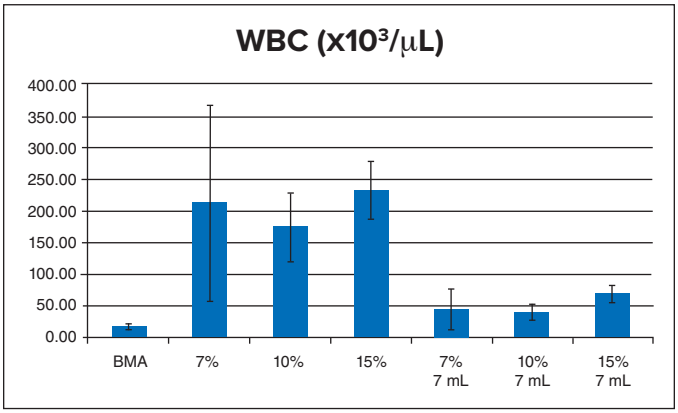



**Figure 5:** WBC concentration in BMA and Angel cPRP$_{BMA}$.

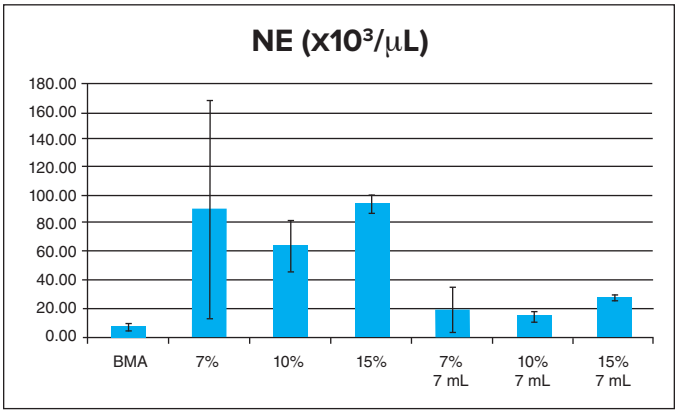



**Figure 6:** NE concentration in BMA and Angel cPRP$_{BMA}$.

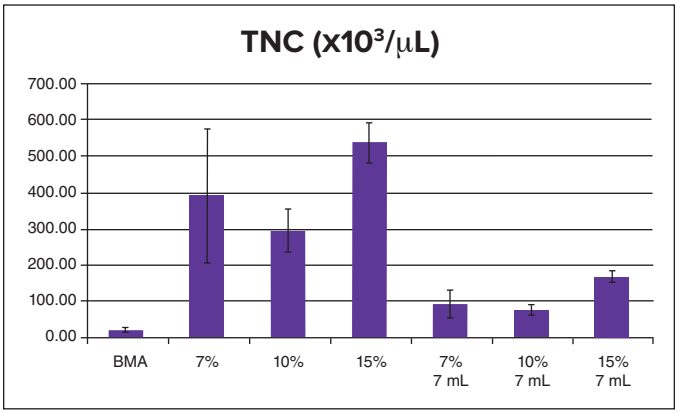



**Figure 7:** TNC concentration in BMA and Angel cPRP$_{BMA}$.

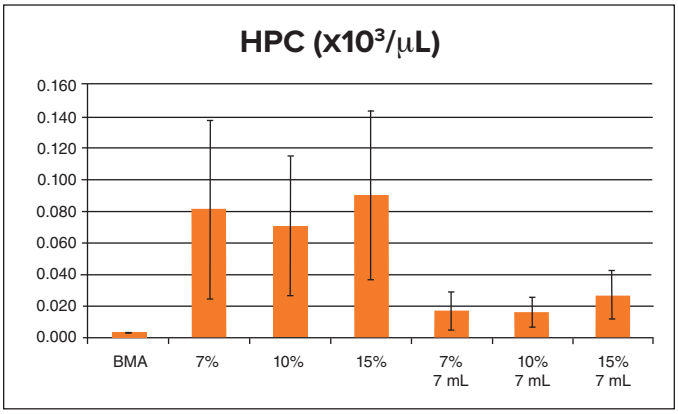



**Figure 8:** HPC concentration in BMA and Angel cPRP$_{BMA}$.

## Discussion

**Advanced Technology of Arthrex Angel® cPRP and Aspiration System:** The Arthrex Angel system uses 3ST to more precisely separate cell types after centrifugation. All cells have a density range and do not separate uniformly after centrifugation. What makes the Arthrex Angel system unique is the ability to isolate specific cells using inherent properties of cells that absorb differing wavelengths of light. In this study, when the HCT setting was increased from 7% to 15%, the Angel system isolated cells from a deeper portion of the buffy coat, which resulted in capturing more HPCs per volume. Another unique feature in the Arthrex Angel system is the manual control of $cPRP_{BMA}$ volume. If the desired $cPRP_{BMA}$ volume is greater than 1.5 mL, the $cPRP_{BMA}$ syringe plunger can be pulled back to that volume. The $cPRP_{BMA}$ volume is expanded with autologous PPP, which consists of anabolic growth factors and other beneficial plasma proteins.

**Total Nucleated Cells vs Hematopoietic Stem Cells:** While TNC concentration is one factor in determining cellular content of BMA, it encompasses a large spectrum of cells, (see **Table 1)**. TNC counts are not a direct indicator of the presence of any specific population of stem cells. It is true that the majority of mesenchymal stem cells (MSCs) and HPCs are stratified within the TNC layer. However, an elevated TNC count does not necessarily correlate to a high MSC or HPC concentration. An increased TNC count can be obtained from concentrating peripheral blood in a buffy coat PRP device. The TNC count would be elevated several times above baseline, but there would not be any significant population of stem cells. Elevated levels of TNCs are only the starting point to determine whether BMA was concentrated. The primary emphasis should be focused on determining if the desired cell types are present and the quality of those cells.

## References


1. Pittenger MF, Mackay AM, Beck SC, et al. Multilineage potential of adult human mesenchymal stem cells. *Science*. 1999;284(5411):143-147.
2. Jones E, McGonagle D. Human bone marrow mesenchymal stem cells in vivo. *Rheumatology*. 2008;47(2):126-131. doi:10.1093/rheumatology/kem206.



ABS-10060 Arthrex Angel System