ASPIRE MEDICAL INNOVATION

Comparison of Two Methods to Harvest Vertebral Body Marrow Aspirate:

Novel Lateral Aspiration Device Compared to Standard Cannula Needle

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INTRODUCTION

Bone marrow aspiration from the iliac crest was initially developed in immunology, hematology and oncology for use in stem cell transplants for treatment of various disorders including leukemia and sickle cell disease.[1,2] The success of clinical protocols in treatment has been linked to the number of stem cells in the graft where minimum thresholds have been established based on the body weight of the recipient.[3] Research has demonstrated that long bones have diminished levels of cellularity in adults. Consequently, the iliac crest has evolved to the primary anatomic location to obtain marrow for these indications because of easy access, large anatomic marrow volume, and due to the high cellularity quality observed.[4] Use of bone marrow in orthopedic surgery has become a standard practice for hydration of graft material to stimulate osteogenesis. Success in orthopedic grafting has also been linked to a certain minimum threshold of stem cells in the graft.[5,6,7,8,9] Unlike transfusion medicine where the volume of fluid delivered is not tightly constrained (typical grafts often exceed a volume of 1,000 cc), a unique challenge in orthopedics is that the size of the graft is typically in the 5cc to 20cc range. For similar reasons to work in immunology, hematology and oncology, the iliac crest has become the primary anatomic location for harvesting bone marrow for orthopedic surgery cases.

Using concentrated marrow aspirate from the iliac crest, Hernigou et al established a minimum stem cell threshold of 1,500 CFU-f per mL for successful bone union clinical outcomes. The study was composed of a diverse patient population including elderly patients and multiple comorbidities.[5] It is notable that the only CFU-f per mL stem cell measurements rose to clinical significance in determining clinical outcomes.[5] Muschler et al, reported connective tissue progenitor cell mean concentrations of 465.67 ±434 cells/cc marrow for 168 vertebral body aspirations as compared to 356 ±469 cells/cc marrow for 168 iliac crest aspirations using a traditional aspiration needle drawing a 2 mL sample volume.[10] Hegde et al reported concentrations of connective tissue progenitor cells for iliac crest needle aspiration of bone marrow in a two arm comparison of three aspiration systems. The reported mean connective tissue progenitor cell concentrations of iliac crest harvest was 1,014 ±958 and 134 ±158, followed by 1,270 ±1,009 and 514 ±355 for the two-arm comparison of three systems.[10]

Although not as widely studied as the iliac crest, the vertebral body has also been reported to be a rich source of stem cells.[10] While not commonly accessed for surgical procedures, marrow aspiration from the vertebral body is directly accessible for posterior spine procedures. A challenge aspect of harvesting clinically relevant samples from the vertebral body is the low anatomic volume as compared to the iliac crest. Nevertheless, hematology literature has reported that aspiration of larger volumes of bone marrow from a single entry site reduces the quality of the aspirate through introduction of peripheral blood, thereby significantly reducing the connective tissue progenitor cell count.[12,13,14]

Objective

This pilot study was designed with the objective of reporting the cellular content of the vertebral body by comparing the average number of connective tissue progenitor cells (CFU-f per /mL) using a novel aspiration technology (Marrow Cellution, (MC)) that employs small draws from a single puncture that promote only lateral flow from multiple sites (SSLM Method), and by using traditional aspiration needle (BMAC) as a control. A secondary purpose of the study was to retrospectively compare the two different sample aspiration protocols tested in this study to previous studies where the aspiration was taken from the iliac crest or vertebral body.

Study Design

Five sets of bone marrow aspirate samples were collected during spine surgery from alternate sides of the same vertebral body with the traditional BMAC technique and the SSLM method. Samples were randomly assigned with respect to the order of aspiration and with respect to the side of the vertebral body where the aspirate sample was harvested. All bone marrow aspirates (BMA) were concentrated in the operating room. Samples arrived at the testing lab within 24 hours of collection. The BMA was tested according to the most recent manufacturer instructions. Primary test parameters included total nucleated cell (TNC), fibroblast- like colony- forming units (CFU-f), and CD34+ cell counts using the ISHAGE protocol.

Results

Table 1 shows the average value for TNC in millions (total nucleated cell), CFU-f and CD 34+ for the samples collected.

Table 1:

N=5	SSLM Method	Aspirate	BMAC
TNC x10^6/mL	68.5	14.4	17.51
CD 34+ /mL	595,654	102,690	131,122
CFU-f /mL	5,309	413	882

Discussion

The vertebral body is a unique anatomic structure. In this pilot study we demonstrated that a smaller aspirate volume is superior to a larger aspirate taken from the same anatomic location that is processed by centrifuging to a concentrate. This finding is consistent with others who have demonstrated a smaller volume aspirate has a higher concentration of stem cells per mL.[15] The aspirate obtained through the SSLM Method is not filtered or concentrated. Furthermore, the SSLM Method aspirate has been shown to contain a full range of cells typically found in marrow.

The entire density range of marrow cells has been shown to have progenitor cells present and filtering marrow can cause a loss of these valuable cells. Muschler et al reported that eight 2 mL bone marrow aspirate samples from the anterior iliac crest in 10 subjects provided an average single aspirate of 58 x10^6 nucleated cells (TNC) and 2,142 connective tissue progenitor cells per aspirate.[16] Vertebral body aspirates from this pilot study were comparable to reported results for the iliac crest: TNC of 68.5 x10^6 and 5,309 CFU-f cell per mL.

Several limitations are associated with this pilot study. First, while suitable for a pilot study, the sample size is small. Future studies should incorporate a larger sample size. Second, while higher numbers of stem/progenitor cells have been associated with regeneration and healing, future studies should include patient follow-up with suitably designed assessment parameters. Third, comparison of pilot study results to historical CFU-f data has limitations given significant patient-to-patient variability.

Conclusion

This pilot study has demonstrated several benefits of the SSLM Method for aspirating bone marrow from the vertebral body. First, the novel cannula design repositions the aspiration needle to provide for aspiration of marrow from the vertebral pedicle across multiple stepped levels of the vertebral body marrow space. Secondly, the SSLM techinque allows the clinician to work with the marrow sample entirely in the sterile field. Thirdly, all cells and growth factors are retained in the SSLM Method aspirate and minimal sample morbidity is incurred. While this pilot study was not designed to be an equivalence study, vertebral body bone marrow aspirate connective tissue progenitor cell concentrations (CFU-f cell per mL) were determined to be comparable to iliac crest bone marrow aspirate connective tissue progenitor cell concentrations. Therefore, these pilot study results suggest that the vertebral body aspirate collected through the SSLM Method could provide comparable CFU-f data to iliac crest marrow aspirate.

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