Introduction: The use of stem cells for regenerative therapies has generated great interest for orthopaedic applications. A primary stem cell source is the patient’s autologous bone marrow (BM). Studies have demonstrated the efficacy of concentrated autologous BM in spine fusion, fracture nonunions and avascular necrosis. However, the clinical success is largely dependent on the prevalence of stem cells in the BM. Current BM harvest procedures utilize percutaneous needle aspiration and lack efficiency and reliability in obtaining a high volume of high quality, stem cell rich marrow. Therefore, there is a clinical need to develop a novel bone marrow harvesting flexible shaft instrument (FSI) to aspirate bone marrow in a swine model as compared to standard BM aspiration needles.

Materials and Methods: The bone marrow harvesting FSI (MarrowMiner, StemCor Systems Inc.) is a hand-held, battery powered instrument, comprised of a flexible catheter with a distal rotating wire loop tip, a cannula with suction ports and a detachable aspiration chamber. Standard single port (Alligience Healthcare) and 6-port needles (Radius medical) were used as comparison. Five juvenile Yorkshire swine were used as experimental subjects. Prior to marrow harvesting, iliac crests were exposed for direct visualization of the aspiration devices. For each pig, 1- and 6-port needles were used to collect marrow at three locations 2 cm apart along the left iliac crest. On the right iliac, FSI was used to collect marrow either along the crest or longitudinally down the plane of the iliac wing. When used in the longitudinal path, bone marrow was harvested in three sequential steps: while the device was entering the ilium (entry), when it reached the distal end (distal), and while the device was being pulled out of the bone (retract). Harvests were collected in three volume ranges: small (2-5ml), medium (5-20ml), and large (>20ml). Total viable cells were quantified using a hemacytometer with trypan blue exclusion. Nucleated cells were counted after incubation with methylene blue in 3% acetic acid. CFU-F assay was used to determine the number of marrow stromal cells per marrow volume following standard culture procedures. Two-way ANOVA without interaction was used to compare the results among individual samples. A p value less than 0.05 was considered significant.

Results: The FSI was observed to be a safe instrument for bone marrow harvest. Despite its long aspiration path (up to 20 cm), the catheter remained within the marrow cavity without penetrating the cortical walls. Up to 60 ml of marrow could be aspirated in a single path using either a syringe or vacuum suction.

No significant differences were observed in nucleated cell concentration among marrows harvested by 1-port, 6-port, and FSI in a longitudinal manner, with the exception that bone marrow aspirated along the iliac crest by FSI contained a significantly higher concentration of nucleated cells. As expected, the CFU-F concentration decreased with increasing bone marrow volume harvested when standard needles were used (Fig.1). In contrast, no significant decrease in CFU-F concentration was observed with increasing marrow volume when FSI was used. Bone marrow aspirated along the crest by FSI contained significantly higher CFU-F than those obtained by needles, regardless of aspiration volume. FSI yielded significantly higher CFU-F concentration than the 1-port and 6-port needle at the medium harvest volume. In addition, when a large volume of marrow was aspirated, FSI harvested significantly higher CFU-F concentration than 6-port needle. As aspiration volume increased from medium to large, FSI aspirate maintained CFU-F concentration while the 6-port needle resulted in an approximately 7.5 fold reduction. In terms of total CFU-F yield, FSI consistently harvested higher numbers of total CFU-Fs than the 1 port (1.4-6.6 fold increase) or 6 port needle (5.3-8.8 fold increase).