Regenerative Potential of Lyophilized Exosomes from Umbilical Cord Stem Cells in Injury Anterior Cruciate Ligament Cells

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INTRODUCTION: Effective healing of anterior cruciate ligament (ACL) injuries is crucial for safe return to sports. Exosomes derived from stem cells have shown potential to enhance tendon and ligament repair, but their clinical use is limited by challenges in storage and delivery. This study investigated the regenerative effects of lyophilized exosomes from human umbilical cord stem cells (hUSC-EX) on chronically injured ACL cells.

METHODS: ACL cells were harvested from rabbits 8 weeks post-injury under IACUC approval (#110232). Exosomes were isolated from human umbilical cord stem cell cultures (IRB #A202205014), lyophilized for long-term storage, and rehydrated before application. Injured ACL cells were treated with hUSC-EX and compared to untreated controls from the same animals. Cell viability, proliferation, and migration were assessed, along with gene expression levels of type I/III collagen, TGF-β, VEGF, and tenogenic markers.

RESULTS: Lyophilized hUSC-EX maintained an average particle size of 84.5 ± 70.6 nm and expressed characteristic exosomal markers (Alix, TSG101, CD9, CD63, CD81), with no expression of α-Tubulin (Figure 1). After 24 hours of treatment, hUSC-EX significantly improved cell viability, proliferation, and migration in injured ACL cells (Figure 2). Expression of genes related to collagen production, growth factors, and tenogenesis was also significantly upregulated (Figure 3).

DISCUSSION: Lyophilized hUSC-EX preserve key exosomal properties and biological activity after storage, offering a practical, ready-to-use therapeutic option. Their application enhances cellular function and pro-regenerative gene expression in chronically injured ACL cells. These results support their potential use in promoting tissue repair, particularly in partial ACL tears or remnant-preserving ACL reconstruction strategies.

SIGNIFICANCE / CLINICAL RELEVANCE: Lyophilized hUSC-EX present a stable, off-the-shelf therapeutic with strong regenerative potential for ACL injuries. Their ease of storage and use, combined with their efficacy, positions them as a promising biomaterial in sports medicine and orthopedic applications.

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IMAGES AND TABLES:

Figure 1.

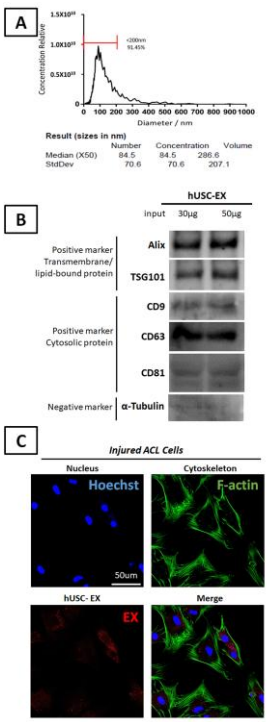

Figure 2.

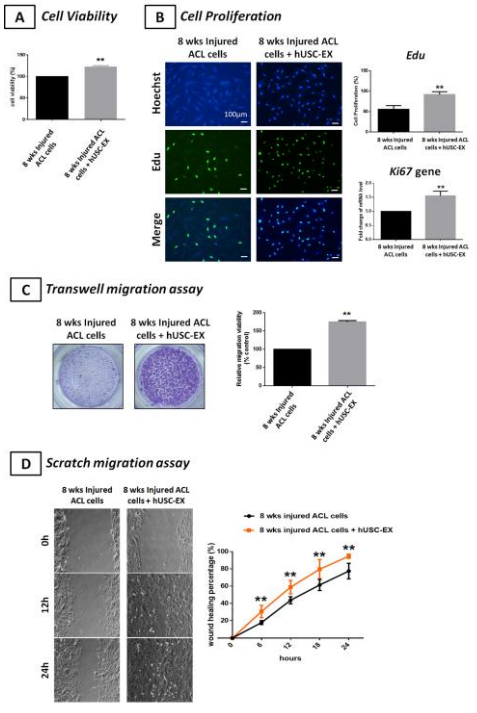

Figure 3.