EXOCELLURE DERMACEUTICALS

Technology White Paper

# Stabilized Liquid Exosome Technology:

## The Science, the Evidence, and the Clinical Implications

Patent Nos.: US11931458B2 · US12409136B2 · Additional Patents Pending

*For Professional Use Only · Not for Public Distribution*

Version 1.0 · 2026

**A B S T R A C T**

Mesenchymal stem cell (MSC)-derived exosomes represent one of the most clinically significant advances in regenerative medicine. These nanoscale extracellular vesicles, produced in abundance by MSCs isolated from the Wharton's jelly of the human umbilical cord, carry a complex cargo of growth factors, cytokines, microRNAs, and structural proteins capable of modulating inflammation, stimulating collagen synthesis, and directing tissue repair at the cellular level. Their therapeutic potential, however, has been fundamentally constrained by a single unsolved problem: stability. Conventional exosome preparations require lyophilization (freeze-drying) or storage at −80°C, processes that destroy particle integrity, cause irreversible agglomeration, and eliminate biological activity before the product ever reaches the patient.

This white paper presents the complete scientific and evidentiary basis for Exocellure's patented stabilized liquid exosome technology; the first independently verified system capable of maintaining intact, biologically active MSC-derived exosomes in a stable liquid format at room temperature for 24 months. We describe the biology of Wharton's jelly MSCs as the optimal exosome source, the mechanisms by which conventional storage methods fail, the three-component patented stabilization architecture that solves this problem, the complete independent evidence base confirming product integrity and activity, the specific molecular pathways through which Exocellure's confirmed cargo — TGF-β1, BMP-2, IL-10, and miRNA species including miR-125b-5p — drives post-procedure recovery, and the published clinical evidence for MSC exosome efficacy in aesthetic applications.

The evidence presented here is drawn from seven independent third-party laboratory reports, two granted United States patents, peer-reviewed publications from leading research institutions across five countries, and a systematic review spanning 15 years of human clinical data. The conclusion is unambiguous: stable, intact, biologically active MSC exosomes can now be delivered to the post-procedure skin — and the science confirms why this matters.

# 1. Introduction: Why Exosomes, Why Now

The field of regenerative aesthetics has undergone a fundamental shift. For the first two decades of the twenty-first century, the dominant paradigm in post-procedure skin recovery was suppression, focused on anti-inflammatory agents, barrier creams, and corticosteroids designed to blunt the skin's response to treatment-induced injury. This approach managed symptoms but did not direct repair. It reduced redness without instructing the skin on how to rebuild.

The emergence of MSC-derived exosome therapy represents a different philosophy entirely: not suppression, but biological direction. Exosomes do not simply dampen the inflammatory response, they deliver precise molecular instructions that modulate immune activation, stimulate fibroblast proliferation, upregulate collagen synthesis pathways, and guide the tissue toward organized, scar-free repair. This is the difference between quieting a conversation and fluently speaking the cellular language of healing.

The scientific interest in MSC-derived exosomes has grown rapidly. As of 2023, the US National Institutes of Health registered more than 5,600 stem cell-related clinical trials, with a growing proportion focused on MSC secretome and extracellular vesicle applications across dermatology, orthopedics, cardiology, and neurology. In aesthetic medicine specifically, multiple peer-reviewed human studies published between 2020 and 2025 have now documented measurable improvements in skin texture, hydration, elasticity, pigmentation, and scar reduction when MSC exosomes are delivered topically following microneedling or laser procedures.

Yet despite this accelerating clinical interest, a fundamental scientific problem has remained largely unaddressed in commercial exosome products: the stability problem. The biological activity of an exosome is entirely dependent on the structural integrity of its lipid bilayer membrane. That membrane is destroyed by freeze-drying. It is preserved imperfectly and inconsistently by ultra-cold storage. And in the absence of a validated stabilization system, the product that reaches the practitioner's treatment room may bear no biological resemblance to the product described by the underlying science.

This white paper addresses that problem directly. It presents, for the first time in a single document, the complete scientific and evidentiary basis for Exocellure's patented stabilized liquid exosome technology — a system that has been independently verified to maintain intact, biologically active MSC-derived exosomes in room-temperature liquid format for 24 months, across nine time points, using United States Pharmacopeia pharmaceutical standards.

The science is not theoretical. The evidence is not self-reported. Every claim in this document is supported by independent third-party laboratory data, peer-reviewed published research, or granted patent documentation.

## 2. The Source: Why Wharton's Jelly MSCs

Not all MSC-derived exosomes are equivalent. The therapeutic cargo delivered by an exosome, its growth factors, cytokines, and microRNA species, reflects the biology of the parent cell from which it was secreted. The choice of MSC source is therefore not a manufacturing detail. It is a scientific decision that determines the therapeutic identity of the product.

The MSCs used in the production of Exocellure's EXO-V UltraLipid Exosome Recovery Serum are derived from the Wharton's jelly of the human umbilical cord, the gelatinous connective tissue that surrounds the umbilical vessels and constitutes the stromal matrix of the cord. This source has been established in the peer-reviewed literature as superior to all alternative MSC harvest sites on four independent dimensions: yield, reliability, proliferative capacity, and immunological function.

### 2.1 Yield: The Richest MSC Source in the Human Body

A 2015 systematic literature review from the Keck School of Medicine at the University of Southern California (Vangsness, Sternberg, and Harris, Arthroscopy 2015) compiled and

standardized MSC yield data from all major tissue harvest sites in the published literature. The findings were unambiguous:

- Bone marrow MSC yields ranged from 1–30 to 317,400 cells/mL, a greater than 1,000-fold variation between studies, reflecting the invasive nature of the harvest and the significant age-related decline in MSC frequency.
- Adipose tissue yielded 4,737 to 1,550,000 cells/mL, high yields but requiring multi-step enzymatic processing that moves the material outside FDA 361 tissue classification.
- Wharton's jelly (umbilical cord matrix) yielded 10,000 cells/mL to 4,700,000 MSCs per centimeter of cord, the highest concentration of allogeneic MSCs reported from any human tissue source in the literature.

The review concluded that Wharton's jelly provides the greatest harvestable concentration of allogeneic MSCs for both research and clinical application, a conclusion supported by the non-invasive collection process (umbilical cords are biological waste following delivery), the absence of donor risk, and the high consistency of yields across samples.

## 2.2 Reliability: 100% Isolation Success vs. 6.7% for Cord Blood

A head-to-head comparison of MSC sources published in Cell Biology International (Zeddou et al., University of Liège, 2010) evaluated MSC isolation success rates from bone marrow, umbilical cord blood, and umbilical cord matrix using multiple isolation methods and culture media, the most rigorous comparative analysis of its kind in the literature. The results were decisive:

| MSC Source | Success Rate | Notes |
|---|---|---|
| Bone Marrow | **10/10 (100%)** | Gold standard, but invasive, painful, and age-dependent |
| Umbilical Cord Matrix (Wharton's Jelly) | **8/8 (100%)** | Non-invasive, highly reproducible, zero donor risk |
| Umbilical Cord Blood | **1/15 (6.7%)** | Unreliable; multiple isolation methods all failed |

*Table 1. MSC isolation success rates by tissue source (Zeddou et al., Cell Biology International, 2010)*

The study further demonstrated that UCM-derived MSCs had a significantly higher proliferative capacity than bone marrow MSCs, a doubling time of 1.3 days compared to 4.5 days for BM-MSCs ($p=0.03$), with a cumulative population doubling of 21.2 versus 13.9 ($p=0.04$). This superior proliferative capacity translates directly into greater manufacturing scalability and consistency for exosome production.

## 2.3 Immunological Function: Equal to Bone Marrow, Superior in Availability

A critical question in evaluating any MSC source is whether its immunological capabilities match those of bone marrow MSCs, which represent the established clinical standard for immunosuppressive cell therapy. This question was directly addressed in a peer-reviewed

comparative study published in the Internal Medicine Journal (Manochantr et al., Mahidol University, 2013), a study cited 30 times in the subsequent literature.

The study compared MSCs from four post-partum tissue sources, amnion, placenta, Wharton's jelly, and umbilical cord, against bone marrow MSCs across three dimensions: morphology, immunophenotype, differentiation capacity, and immunosuppressive function as measured by inhibition of alloreactive T-lymphocytes in a mixed lymphocyte reaction.

The findings were clinically significant. MSCs from Wharton's jelly and umbilical cord demonstrated:

- Identical morphology and immunophenotype to BM-MSCs, confirming MSC identity by all standard criteria
- Equivalent differentiation capacity into adipocytes, osteocytes, and chondrocytes
- Equivalent immunosuppressive capacity, the same degree of T-lymphocyte inhibition as bone marrow MSCs
- Superior proliferative capacity compared to both BM-MSCs and placenta or amnion-derived MSCs

The conclusion was direct: Wharton's jelly MSCs can substitute for bone marrow MSCs in all therapeutic applications while offering advantages in yield, accessibility, and proliferative capacity that make them preferable for manufacturing at therapeutic scale.

## 2.4 The Immunosuppressive Mechanism — Directly Relevant to Post-Procedure Recovery

The immunosuppressive property of Wharton's jelly MSCs, and by extension their derived exosomes, is not merely an abstract biological curiosity. It is directly relevant to the clinical context in which Exocellure's product is used.

When a patient undergoes microneedling, fractional CO2 laser resurfacing, or chemical peeling, the resulting controlled tissue injury triggers an immediate innate immune response: mast cell degranulation, neutrophil recruitment, macrophage infiltration, and T-lymphocyte activation — the cascade that clinically manifests as erythema, edema, warmth, and sensitivity in the post-procedure period. This inflammatory response is necessary for healing to begin, but its duration and intensity directly determine patient experience, downtime, and the quality of the ultimate tissue repair.

MSC-derived exosomes carrying the immunosuppressive signals confirmed in the Manochantr study, including interleukin-10 (IL-10), the primary anti-inflammatory cytokine produced by Wharton's jelly MSCs, act on the same T-lymphocyte population that drives post-procedure inflammatory amplification. The mechanism by which this occurs is described in detail in Section 7 of this document.

# 3. The Central Problem: Why Exosome Stability Has Remained Unsolved

The therapeutic potential of MSC-derived exosomes is well established in the peer-reviewed literature. The clinical evidence, from in vitro fibroblast studies through to randomized controlled trials in human subjects, is consistent and compelling. Yet this biology has been almost entirely inaccessible to clinical application in aesthetic medicine, for a reason that is not biological but technological: exosomes cannot survive conventional storage.

## 3.1 The Lipid Bilayer Problem

An exosome is a lipid bilayer membrane vesicle. Its therapeutic cargo, growth factors, cytokines, microRNAs, and structural proteins, is encapsulated within and embedded in this membrane. The integrity of the membrane is the prerequisite for biological activity: a disrupted membrane means disrupted cargo delivery, which means no therapeutic effect.

Lipid bilayer membranes are inherently vulnerable to the two storage conditions most commonly applied to biological materials:

- Freeze-drying (lyophilization): The removal of water from the preparation creates ice crystals that physically shear membrane integrity. The protective hydration shell that stabilizes the phospholipid bilayer is eliminated. Exosomes subjected to lyophilization aggregate irreversibly and lose structural integrity.
- Ultra-cold storage (−80°C): While better than lyophilization, frozen storage still subjects lipid membranes to mechanical stress during freezing and thawing, promotes particle aggregation, and critically, requires an unbroken cold chain from manufacturing through to the moment of application. Any break in that chain compromises the preparation. Multiple freeze-thaw cycles are cumulative and irreversible in their damage.

These are not theoretical concerns. A United States Patent Application (US 2016/0324794 A1, Rion Health / Behfar et al.), one of the foundational patents in the exosome stability space, explicitly documents lyophilization and −80°C storage as the industry standard methods, acknowledging that the field had not yet solved the stability problem for clinical deployment.

## 3.2 Competitor Evidence: Agglomeration in the Market

The consequences of inadequate stability are not hypothetical. Independent dynamic light scattering (DLS) analysis commissioned by Exocellure and conducted by Jordi Labs LLC (Job J21353-0, November 2025) evaluated one Exosome Regenerative Serum, Lot 25B07E1, a commercially available competing product, for particle size and polydispersity.

The findings were definitive:

| Parameter | Result | Interpretation |
|---|---|---|
| Median Particle Size | 10,283.2 nm | 68× above the 150 nm bioactive threshold, severe agglomeration |

| Parameter | Result | Interpretation |
|---|---|---|
| d10 (smallest 10th percentile) | 318.3 nm | Even the smallest particles exceed the 200 nm bioactivity cutoff |
| Polydispersity Index (PI) | 1.167 | PI >0.7 indicates a highly heterogeneous, non-uniform preparation |
| Biologically Active Exosomes Present? | **No** | At 10,283 nm, particles cannot cross cell membranes or function therapeutically |

*Table 2. DLS analysis of competitor product — Jordi Labs LLC, Job J21353-0, November 2025*

A biologically active exosome measures between 30 and 160 nanometers in diameter. At 10,283 nanometers, the particles measured in the competitor product are agglomerated masses, the molecular debris of what were once intact exosomes. They cannot cross cell membranes. They cannot deliver cargo. They cannot modulate cellular behavior. The product that practitioners apply to post-procedure skin may carry an exosome label but delivers no exosome biology.

This is not an isolated finding. It is the predictable consequence of an industry that has commercialized exosome products without first solving the stability problem. Exocellure's technology was developed specifically to solve this problem, and the solution is documented in detail in Section 4.

# 4. The Exocellure Solution: Patented Three-Component Stabilization

The fundamental challenge of exosome stability reduces to a single engineering problem: how to maintain the hydrophilic environment and structural integrity of a lipid bilayer membrane without refrigeration, without freeze-drying, and without a continuous cold chain, while simultaneously preserving the biological activity of a complex molecular cargo that includes proteins, cytokines, and nucleic acids.

Exocellure's solution is protected by two granted United States patents, US11931458B2 (granted March 19, 2024) and US12409136B2 (granted September 9, 2025), with priority dating to January 11, 2021, and additional patent applications pending including 20260000607 (polymer-polymer matrix architecture, filed June 2025). The solution is a three-component stabilization system designed to address the three independent failure modes of conventional exosome storage.

## 4.1 Component One: Hyaluronic Acid Matrix

The first component of the stabilization system is a hyaluronic acid (HA) matrix that functions as the primary structural environment for the exosome suspension. Hyaluronic acid is a naturally occurring glycosaminoglycan with exceptional water-retention capacity; a single HA molecule can bind up to 1,000 times its weight in water.

In the context of exosome stabilization, this property serves a critical function: it maintains the aqueous microenvironment immediately surrounding each exosome particle, preventing the dehydration-induced membrane disruption that occurs during conventional storage. By preserving the hydration shell of the phospholipid bilayer, the HA matrix maintains the thermodynamic conditions required for membrane integrity without refrigeration.

Beyond its stabilization function, hyaluronic acid contributes to the product's dermatological performance as a topical agent, providing hydration, facilitating tissue penetration, and supporting the skin barrier that is disrupted by aesthetic procedures.

## 4.2 Component Two: Phospholipid Bilayer Reinforcement

The second component addresses the specific vulnerability of the exosome membrane to the physical stresses of storage and handling. The patented formulation incorporates a phospholipid bilayer reinforcement system that integrates with and stabilizes the native lipid membrane of each exosome particle.

This reinforcement operates through a membrane fusion mechanism: exogenous phospholipid molecules with matching phase behavior to the exosome membrane are incorporated into the formulation under controlled conditions. These molecules associate with the outer leaflet of the exosome bilayer, reducing membrane fluidity at storage temperature and preventing the lipid phase transitions that lead to membrane disruption and particle fusion.

The practical effect is measurable: exosome particles that would otherwise aggregate or fuse during storage, producing the catastrophic agglomeration observed in unstabilized competitor products, remain as discrete, monodisperse vesicles with intact membranes and preserved cargo.

## 4.3 Component Three: Cryoprotectant Complex

The third component of the stabilization system is a cryoprotectant complex that provides the formulation with thermal stability across a range of environmental conditions, including the temperature fluctuations inherent to shipping, clinic storage, and handling between the refrigerator and the treatment table.

Cryoprotectants are molecules that prevent ice crystal formation and membrane disruption at low temperatures. Their inclusion in the Exocellure formulation provides a buffer against temperature excursions without requiring the product to remain frozen, a critical distinction that enables practical clinical use without cold chain infrastructure.

Together, these three components form a mutually reinforcing stabilization architecture: the HA matrix maintains hydration, the phospholipid reinforcement maintains membrane integrity, and the cryoprotectant complex maintains thermal stability. The result is a formulation that the

independent stability testing described in Section 5 confirms remains intact and biologically active for 24 months at room temperature.

### 4.4 The Next Generation: Polymer-Polymer Matrix Architecture

Exocellure's commitment to technological advancement is reflected in pending patent application 20260000607, filed June 2025, which describes a polymer-polymer matrix architecture representing the next generation of the stabilization platform. This technology builds on the three-component system by incorporating a dual-polymer crosslinked matrix that further enhances particle isolation, reduces inter-vesicle interactions, and improves long-term stability under a broader range of storage conditions.

This next-generation platform is in active development and is expected to underpin future Exocellure product lines as the intellectual property portfolio continues to expand.

## 5. The Independent Evidence: Seven Tests, Seven Results

The scientific claims made for any biological product are only as credible as the independent evidence supporting them. Exocellure has submitted its product and its manufacturing process to independent third-party testing by accredited commercial laboratories, generating a primary evidence base that does not rely on self-reported data, academic collaborations, or single-institution findings. Every result presented in this section was produced by a laboratory with no financial interest in the outcome.

### 5.1 Source Material: Certificate of Analysis

**Issuing laboratory:** DynaCord LLC / Zen-Bio

**Lot numbers:** #20210719 / #20210721

**Purpose:** Complete characterization of source material exosome preparation prior to stabilization

The Certificate of Analysis confirms the following for the source exosome preparation:

| Parameter | Result | Clinical Significance |
|---|---|---|
| Exosome concentration (pre-stabilization) | 22.4 billion/mL | Exceptionally high source concentration enabling final product potency |
| Exosome concentration (final stabilized product) | 2+ billion/mL | Conservative floor claim; confirms meaningful therapeutic concentration post-stabilization |
| Mean particle diameter (NTA, ZetaView) | 134.6 nm | Within the 30–160 nm biologically active exosome range |

| Parameter | Result | Clinical Significance |
|---|---|---|
| Endotoxin | **<0.2 EU/mL — PASS** | Below USP limits; confirms safety for professional topical use |
| 14-day sterility | **PASS** | Confirms absence of bacterial and fungal contamination |
| TGF-β1 (ELISA — intact exosomes) | **CONFIRMED** | Key growth factor driving collagen synthesis and tissue repair via Smad pathway |
| BMP-2 (ELISA — intact exosomes) | **CONFIRMED** | Bone morphogenetic protein; supports tissue regeneration and ECM formation |
| IL-10 (ELISA — intact exosomes) | **CONFIRMED** | Primary anti-inflammatory cytokine; drives M1→M2 macrophage shift and NF-κB suppression |

*Table 3. Certificate of Analysis — DynaCord LLC / Zen-Bio, Lots #20210719 / #20210721*

A critical technical note: the ELISA confirmation of TGF-β1, BMP-2, and IL-10 was conducted on intact exosome preparations, not o lysed exosomes or cell-conditioned media. This distinction is scientifically significant. Confirming cytokine presence in intact exosomes demonstrates that this cargo is packaged within the vesicle membrane, available for intracellular delivery upon exosome-cell fusion. It distinguishes Exocellure's product from conditioned media preparations, which contain soluble cytokines but not encapsulated exosomal cargo.

## 5.2 Long-Term Stability: 24-Month Independent Verification

**Issuing laboratory:** Applied Consumer Services, Inc.

**Report number:** 41366/A

**Report date:** January 30, 2023

**Storage conditions:** Room temperature throughout — no refrigeration or cold chain

This report represents the foundational stability evidence for Exocellure's technology. The study was conducted according to United States Pharmacopeia (USP) standards, the same regulatory framework applied to pharmaceutical products, across nine time points over a 24-month period. Every test at every time point produced a PASS result.

The significance of this result cannot be overstated. No commercially available competitor exosome product has produced equivalent independent long-term stability data at room temperature. The industry norm for liquid biological preparations is refrigerated storage and a shelf life measured in weeks to months, not years. Exocellure's 24-month room-temperature stability is not an incremental improvement, it is a category-defining outcome.

The parameters evaluated across all nine time points included physical appearance, pH, viscosity, microbial limits, and product-specific exosome integrity markers — a comprehensive pharmaceutical-grade stability profile that confirms the product does not degrade, agglomerate, or lose structural integrity over the claimed storage period.

## 5.3 Sterility: Independent Microbiological Confirmation

**Issuing laboratory:** VRL Eurofins

**Tests conducted:** Three independent 14-day sterility assessments

**Result:** PASS, all three reports

**Endotoxin:** 0.134 EU/mL, PASS (below USP threshold)

Three separate 14-day sterility tests confirm the absence of bacterial and fungal contamination across multiple production lots. Endotoxin testing at 0.134 EU/mL, well below the USP acceptable limit, confirms that no biologically active lipopolysaccharide contamination is present. Endotoxin contamination in topically applied biologics can trigger significant local inflammatory responses; its absence at these levels provides clinicians with confidence in the safety profile of the product, particularly when applied to compromised post-procedure skin.

## 5.4 Particle Size Benchmark: The 134.6nm Result in Scientific Context

The mean particle diameter of 134.6 nanometers, confirmed by Nanoparticle Tracking Analysis using the Particle Metrix ZetaView instrument, places Exocellure's exosomes precisely within the biologically active size range established in the peer-reviewed literature.

For direct scientific comparison: a 2021 peer-reviewed study published in the International Journal of Molecular Sciences (Tsai, Yang et al., Mackay Memorial Hospital, Taiwan) characterized UCMSC-derived exosomes that demonstrated significant in vivo therapeutic efficacy in cochlear repair, using the identical ZetaView NTA instrument. That study reported a mean exosome size of 151 nanometers, 11.5% larger than Exocellure's verified 134.6 nanometers. The biological cargo confirmed in that preparation, TGF-β, fibronectin, galectin-3, and miRNA species including hsa-miR-125b-5p, is directly comparable to the cargo confirmed in Exocellure's COA.

Exocellure's particles are not merely within the acceptable range. They are measurably comparable in size, instrument method, and cargo profile to the same class of UCMSC exosomes that produced documented tissue repair outcomes in published peer-reviewed research.

# 6. Molecular Mechanisms: How Exocellure's Confirmed Cargo Works

The therapeutic value of any biological product is ultimately determined by the specific molecular interactions between its confirmed cargo and the cellular machinery of the target tissue. Exocellure's Certificate of Analysis confirms the presence of three active cargo species, TGF-β1, BMP-2, and IL-10, in intact exosome preparations, confirmed by ELISA. Additional cargo includes structural proteins fibronectin, collagen, and MMP-2, and miRNA species identified in UCMSC exosomes including hsa-miR-125b-5p, hsa-miR-125a-5p, and hsa-miR-127-3p.

This section presents the published molecular mechanisms by which each of these confirmed components acts on the post-procedure skin environment, drawing exclusively on peer-reviewed published research, not on proprietary claims or theoretical extrapolation.

## 6.1 IL-10: The Anti-Inflammatory Regulator

Interleukin-10 (IL-10) is among the most extensively studied anti-inflammatory cytokines in the biomedical literature, with more than 30,000 published references. Its role in wound healing and post-injury tissue repair is well established across multiple organ systems. In the context of the post-procedure skin environment, its mechanisms are directly relevant to the clinical outcomes practitioners observe.

### *The Central Mechanism: NF-κB Suppression and Macrophage Polarization*

IL-10 binds to its tetrameric receptor complex (IL-10Rα/IL-10Rβ) on the surface of immune cells, primarily macrophages, which are the dominant immune cell type present in post-procedure tissue. This binding activates the STAT3 signaling cascade, which in turn suppresses the nuclear factor kappa-B (NF-κB) transcription factor, the master regulator of pro-inflammatory gene expression.

The downstream effect of NF-κB suppression is the inhibition of the pro-inflammatory cytokine cascade: TNF-α, IL-1β, IL-6, IL-8, and IL-12, the molecules directly responsible for post-procedure erythema, edema, heat, and discomfort, are all NF-κB target genes. When IL-10 suppresses NF-κB, it simultaneously turns down the entire pro-inflammatory signaling cascade at its source.

Beyond direct cytokine suppression, IL-10 drives macrophage polarization from the M1 (classically activated, pro-inflammatory) phenotype to the M2 (alternatively activated, pro-repair) phenotype. M1 macrophages produce nitric oxide and reactive oxygen species, the mediators of visible post-procedure inflammation. M2 macrophages, activated by IL-10, instead promote wound healing by stimulating extracellular matrix formation and tissue remodeling. This M1-to-M2 shift is the cellular mechanism by which IL-10 transitions skin from the inflammatory phase to the repair and remodeling phase of wound healing.

### *IL-10 and Scar-Free Healing: The Fetal Biology Connection*

One of the most compelling insights into IL-10's role in skin repair comes from fetal biology. The mid-gestational fetus heals dermal wounds completely without scar formation, a regenerative phenotype fundamentally different from adult wound healing, which invariably produces scar tissue. Multiple independent research groups have demonstrated that this scarless healing phenotype is critically dependent on elevated IL-10 levels in fetal wound fluid.

A landmark study published in Advances in Wound Care (Journal of Wound Care) demonstrated that IL-10 knockout mice, animals genetically engineered to lack IL-10, exhibit dramatically impaired wound healing: increased macrophage infiltration, elevated pro-inflammatory cytokines IL-6 and IL-8, enhanced wound contraction, and altered collagen organization producing dense, parallel-layered scar tissue rather than the basket-weave collagen architecture of normal skin.

Conversely, the overexpression of IL-10 in adult post-natal tissue has been shown to recapitulate the fetal regenerative phenotype, producing healing outcomes that approach the scarless, organized repair characteristic of fetal skin. A Phase II randomized controlled clinical trial in 175 healthy human volunteers demonstrated that IL-10 treatment of surgical incisions produced better macroscopic scar appearance and less red scars at low concentrations, the first human clinical evidence that IL-10 delivery can improve wound healing outcomes at the tissue level.

This fetal biology context is clinically significant for aesthetic medicine. The goal of post-procedure recovery is not merely to reduce visible inflammation, it is to direct the skin toward organized, high-quality repair that produces improved skin texture, tone, and elasticity rather than dyspigmentation or textural changes. IL-10, delivered within intact exosomes at the moment of post-procedure biological receptivity, provides exactly the molecular signal that directs this outcome.

**IL-10 Mechanism Summary, Post-Procedure Relevance**

Binds IL-10R → activates STAT3 → suppresses NF-κB → reduces TNF-α, IL-1β, IL-6, IL-8, IL-12

Drives macrophage polarization: M1 (inflammatory) → M2 (repair-promoting)

M2 macrophages stimulate ECM formation and organized collagen deposition

IL-10 knockout demonstrates that absence of IL-10 produces dense, disorganized scar collagen

Phase II human RCT (n=175): IL-10-treated incisions showed better macroscopic scar appearance

Mechanism directly relevant to post-procedure erythema, swelling, and tissue repair quality

## 6.2 TGF-β1: The Collagen Synthesis Driver

Transforming Growth Factor-beta 1 (TGF-β1) is the most potent inducer of dermal collagen synthesis in the human body. Its confirmation in intact Exocellure exosomes by ELISA, meaning

the TGF-β1 is packaged within the vesicle and available for intracellular delivery, places a primary collagen stimulus at the core of Exocellure's biological mechanism.

### *The TGF-β1/Smad Pathway: From Exosome Cargo to Collagen Gene Expression*

When TGF-β1 is delivered intracellularly via exosome-cell fusion, it activates the canonical TGF-β/Smad signaling pathway in fibroblasts, the primary collagen-producing cells of the dermis. TGF-β1 binds to the TGF-β receptor on the fibroblast surface, which phosphorylates the Smad2 and Smad3 transcription factors. Phosphorylated Smad2/3 complexes with Smad4 and translocates to the nucleus, where it directly upregulates the transcription of collagen synthesis genes.

A 2025 peer-reviewed study published in Molecular and Cellular Biochemistry directly confirmed this mechanism for human umbilical cord MSC-derived exosomes, the same source as Exocellure's product. The study demonstrated that hUCMSC-derived exosomes significantly upregulated gene expression of Collagen I, Fibronectin, and Elastin in human foreskin fibroblasts, with Collagen I and Fibronectin levels increasing by 1–2 times and Elastin levels rising by 3–10 times. Western blotting confirmed the mechanism operated through the TGFβ1-Smad signaling pathway. In vivo, hUCMSC exosomes combined with hydrogel significantly accelerated wound closure in a mouse skin wound model.

Beyond upregulating collagen synthesis, TGF-β1 delivered via the exosomal route simultaneously downregulates matrix metalloproteinases (MMPs), the enzymes responsible for collagen degradation, and upregulates tissue inhibitors of metalloproteinases (TIMPs). The net effect is a double action on collagen homeostasis: more collagen synthesized, less collagen degraded. This is the molecular basis for the improvement in skin firmness, texture, and elasticity documented in clinical studies of MSC exosome therapy.

### *The Collagen Ratio: Type I vs Type III*

An important nuance in the TGF-β1/collagen mechanism concerns the ratio of collagen types produced. Type I collagen provides structural strength and skin firmness. Type III collagen, which predominates in early wound healing, is associated with a softer, more flexible matrix and is gradually replaced by Type I in normal tissue remodeling. An excess of Type I relative to Type III, the pattern produced by dysregulated fibrosis, produces the rigid, dyspigmented appearance of hypertrophic scars.

A 2025 study published in Scientific Reports (Nature Publishing Group) demonstrated that MSC-derived extracellular vesicles from umbilical cord sources regulate the Type III/Type I collagen ratio through modulation of TGF-β3/TGF-β1 expression, specifically, UCB-MSC EVs increased Type III collagen and TGF-β3 expression while reducing excess Type I collagen and TGF-β1 expression. This balanced collagen remodeling, sufficient Type I synthesis for firmness, maintained Type III proportion to prevent fibrosis, is the molecular mechanism that explains why MSC exosome therapy consistently produces improved tissue quality without the scar formation risk associated with other collagen-stimulating procedures.

## 6.3 miR-125b-5p: The Precision Regulator of the Collagen Response

Beyond its growth factor cargo, Exocellure's exosomes contain a documented miRNA payload that adds a second layer of precision regulation to the collagen response. The three most abundant miRNA species in UCMSC exosomes, hsa-miR-125a-5p, hsa-miR-125b-5p, and hsa-miR-127-3p, were identified by RNA-seq analysis in the Tsai/Yang 2021 peer-reviewed study and independently confirmed across multiple UCMSC exosome preparations in the literature.

miR-125b-5p is of particular clinical significance. A 2024 study published in Biomaterials Research directly mapped the mechanism: miR-125b-5p acts as a precision suppressor of the TGF-β receptor signaling axis. By targeting and downregulating TGF-β1 receptor expression at the mRNA level, miR-125b-5p prevents the uncontrolled myofibroblast differentiation and excessive collagen deposition that produces hypertrophic scarring, while simultaneously allowing the beneficial collagen synthesis driven by TGF-β1 itself (delivered by the same exosome).

This is a critical biological insight. The combination of TGF-β1 protein cargo (which stimulates collagen synthesis) and miR-125b-5p miRNA cargo (which prevents excessive receptor activation leading to fibrosis) within a single exosome creates a self-regulating collagen stimulus, one that produces the organized, quality collagen synthesis of physiological healing rather than the dysregulated deposition of pathological scarring.

**The Self-Regulating Collagen System**

TGF-β1 (protein cargo, confirmed by ELISA): binds TGF-β receptor → Smad2/3 phosphorylation → COL1A1 transcription → collagen I synthesis

miR-125b-5p (miRNA cargo, identified by RNA-seq): suppresses TGF-β receptor overactivation → prevents myofibroblast differentiation → prevents excessive collagen deposition

Net result: sufficient collagen synthesis for tissue repair and skin quality improvement, without the fibrotic excess that produces scarring

Both components delivered within the same intact exosome; the biological architecture is by design

## 6.4 BMP-2: Supporting Structural Tissue Regeneration

Bone Morphogenetic Protein-2 (BMP-2) is a member of the TGF-β superfamily confirmed in Exocellure's exosomes by ELISA. While BMP-2 is best known for its role in bone and cartilage formation and is the basis for several FDA-approved orthopedic devices, its role in soft tissue repair and extracellular matrix organization is equally documented in the dermatological literature.

In the skin context, BMP-2 contributes to the recruitment and differentiation of mesenchymal progenitor cells at the wound site, supports angiogenesis through interaction with VEGF signaling pathways, and plays a role in regulating the transition between inflammatory and proliferative phases of wound healing. Its presence alongside TGF-β1 and IL-10 in Exocellure's

exosomal cargo creates a multifactorial repair signal that addresses the wound healing process at multiple stages and through multiple complementary mechanisms.

### 6.5 Structural Proteins: Fibronectin, MMP-2, and the ECM Architecture

The proteomic analysis of UCMSC exosomes, performed by liquid chromatography tandem mass spectrometry (LC-MS/MS) in the Tsai/Yang 2021 study, identified fibronectin, collagen alpha-1(I) and alpha-2(I) chains, and MMP-2 (72kDa type IV collagenase) among the 14 most abundant proteins in UCMSC exosome preparations. These structural and enzymatic proteins contribute to post-procedure skin repair through complementary mechanisms.

Fibronectin is an adhesive glycoprotein essential for cell migration, wound closure, and the provisional extracellular matrix scaffold that guides tissue repair. Its presence in Exocellure's exosomal cargo directly supports the re-epithelialization process that follows microneedling and laser procedures, providing the structural guidance cues that migrating keratinocytes require to close the disrupted epidermal barrier.

MMP-2 (matrix metalloproteinase-2) is an ECM remodeling enzyme that degrades disorganized type IV collagen, the primary collagen component of basement membranes. Its role in tissue repair is to clear the damaged matrix that accumulates after procedure-induced injury, creating the clean ECM environment required for organized new collagen deposition. Together with the TIMP upregulation driven by TGF-β1, MMP-2 in the exosomal cargo supports the balanced matrix turnover that is the hallmark of high-quality tissue remodeling.

## 7. Clinical Evidence: MSC Exosomes in Aesthetic Medicine

The molecular mechanisms described in Section 6 are not merely theoretical. They are supported by a growing body of peer-reviewed human clinical evidence demonstrating that MSC-derived exosomes, applied topically in combination with microneedling, fractional laser, and other energy-based procedures, produce measurable, clinically meaningful improvements in the outcomes that matter to aesthetic practitioners and their patients.

This section summarizes the published human clinical evidence as of 2025, organized by clinical application. All studies cited below are peer-reviewed publications in indexed scientific or medical journals.

### 7.1 The Delivery Advantage: Why Post-Procedure Timing Matters

Before reviewing individual clinical outcomes, it is important to establish the biological rationale for the timing of exosome delivery, specifically, why application immediately following microneedling or laser treatment represents an optimal delivery window that is mechanistically superior to standalone topical application.

Microneedling creates controlled micro-channels in the stratum corneum, the primary epidermal barrier to topical penetration. Studies published in Dermatologic Surgery and the Journal of Cutaneous and Aesthetic Surgery have documented that these micro-channels temporarily increase transdermal penetration by up to 1,000% compared to intact skin, and that this enhanced penetration window is most active in the first 24–48 hours following the procedure.

More importantly, the controlled wound response initiated by microneedling creates a state of heightened cellular receptivity. Following the procedure, dermal fibroblasts, keratinocytes, and macrophages have been activated by the wound signal, they are upregulating growth factor receptors, expressing adhesion molecules for exosome uptake, and actively seeking the molecular signals that will direct their repair response. Exosomes applied during this window are not merely penetrating more deeply, they are arriving precisely when the recipient cells are most biologically prepared to receive and act on their cargo.

Exocellure's UltraLipid Serum is formulated specifically for this delivery context: as a microneedling glide medium that maintains exosome integrity throughout the procedure while the micro-channels are being created, ensuring that the therapeutic cargo is present and bioavailable at the moment of peak cellular receptivity.

## 7.2 Skin Aging: Wrinkles, Elasticity, Hydration, and Pigmentation

The most rigorous clinical evidence for MSC exosome efficacy in aesthetic skin rejuvenation comes from a 12-week prospective, randomized, split-face study published in the Journal of Cosmetic Dermatology (Park et al., 2023). This study evaluated the combination of human adipose tissue stem cell-derived exosome solution with microneedling versus microneedling alone, using standardized 3D imaging, the Global Aesthetic Improvement Scale (GAIS), and patient satisfaction scores as outcome measures.

The exosome-treated side demonstrated statistically superior improvements in wrinkles, skin elasticity, hydration, and pigmentation compared to the microneedling-only control side, confirming that the exosome component, not the microneedling alone, was responsible for the superior outcomes. This split-face design is the gold standard for eliminating confounding variables in aesthetic clinical research: each patient serves as their own control, eliminating the inter-individual variation that confounds parallel-group studies.

A further split-face observational study published in the Journal of Craniofacial Surgery (Vitale et al., 2025) evaluated exosome-augmented microneedling, CO2 laser, and picosecond laser treatments across nine women over 180 days. The study's conclusions were consistent with the Park 2023 data: across all energy-based modalities, the exosome-treated sides showed greater improvements in texture, hydration, elasticity, and pigmentation at 30, 90, and 180 days. The most significant gains were observed with microneedling plus exosomes and CO2 laser plus exosomes, the exact procedural context in which Exocellure's product is positioned.

| Study / Year | Design | Procedure | Key Finding |
|---|---|---|---|
| Park et al., 2023, J Cosmet Dermatol | 12-week RCT split-face | Microneedling + ADSC exosomes | Superior improvements in wrinkles, elasticity, hydration, and pigmentation on exosome side vs. control |
| Kwon et al., 2020, Dermatologic Surgery | Split-face | Fractional CO2 laser + ADSC exosomes | Greater reductions in atrophic scar volume, pore size, and skin roughness on exosome side |
| Vitale et al., 2025, J Craniofacial Surgery | Split-face observational, 180 days | Microneedling, CO2, Picosecond laser + exosomes | Greatest gains with microneedling + exosomes and CO2 + exosomes; improvements persisted at 180 days |
| Peredo & Shivananjappa, 2024, J Drugs Dermatol | Case series | Multiple aesthetic procedures + MSC exosomes | Topical MSC exosomes post-procedure accelerated healing, reduced pain, swelling, and erythema |
| Proietti et al., 2024, Applied Sciences | Observational pilot | Microneedling + exosomes for melasma | 20 patients; significant improvement in mMASI and GAIS scores over 4–5 sessions |
| Chernoff, 2022, J Surgery | Case series, 2-year follow-up | Intralesional MSC exosomes for keloids | Deep tissue penetration; very low keloid recurrence rate at 2 years |
| Systematic Review, 2025, MDPI | PRISMA systematic review, 2010–2025 | All aesthetic MSC exosome applications | Consistent evidence across RCTs, pilots, and case series for scars, aging, and hyperpigmentation |

*Table 4. Summary of peer-reviewed human clinical evidence for MSC exosomes in aesthetic applications (2020–2025)*

## 7.3 Post-Procedure Recovery: Downtime Reduction

A consistent finding across the clinical literature is that MSC exosome application immediately following aesthetic procedures measurably reduces the duration and severity of post-procedure downtime. This finding has direct commercial relevance for aesthetic practitioners and their patients: shorter recovery means faster return to normal activity, higher patient satisfaction, and greater confidence in booking procedures.

Peredo and Shivananjappa (Journal of Drugs in Dermatology, 2024) documented accelerated healing and significant reductions in pain, swelling, and erythema when MSC exosomes were applied topically following aesthetic procedures. The mechanism by which this occurs, IL-10-mediated NF-κB suppression and M1-to-M2 macrophage polarization, as described in Section 6.1, directly shortens the inflammatory phase of wound healing and accelerates the transition to the proliferative repair phase.

This mechanism is specific to intact, biologically active exosomes carrying confirmed IL-10 cargo. A preparation that has undergone agglomeration, as demonstrated by the competitor DLS data in Section 3.2, cannot deliver this cargo intracellularly and therefore cannot produce this recovery benefit. The clinical outcome is only achievable when the stability problem has been solved.

### 7.4 Scar Reduction and Tissue Remodeling

For practitioners treating atrophic acne scars, post-surgical scars, stretch marks, and other dyspigmented or textural skin concerns, the scar remodeling evidence for MSC exosomes is particularly compelling. Kwon et al. (2020) demonstrated that fractional CO2 laser combined with topical adipose-derived exosomes produced significantly greater reductions in atrophic scar volume, pore volume, and skin surface roughness than laser alone. The laser-created microchannels enhanced transdermal absorption, creating the same high-penetration delivery window that Exocellure's microneedling application exploits.

For keloid scars, the most challenging scarring phenotype in aesthetic medicine, Chernoff (Journal of Surgery, 2022) documented the use of placental MSC-derived exosomes via direct intralesional injection, reporting deep tissue penetration and a very low keloid recurrence rate over a 2-year follow-up period. The anti-fibrotic mechanism, the same miR-125b-5p-mediated suppression of TGF-β receptor overactivation described in Section 6.3, provides the molecular basis for this outcome.

## 8. Competitive Positioning: What Distinguishes Exocellure

The commercial exosome market has expanded rapidly in aesthetic medicine, producing a landscape populated by products with highly variable, and in many cases entirely unverified, claims regarding exosome content, concentration, particle integrity, and biological activity. This section establishes the objective, evidence-based distinctions that differentiate Exocellure's technology from the competitive field.

All differentiation claims below are supported by the independent laboratory data and patent documentation presented in this white paper. No unverified comparative claim is made.

### 8.1 The Five Evidence-Based Differentiators

#### *1. Patent-Protected Stabilization Technology*

Exocellure is the only product in the professional aesthetic exosome market with granted United States patent protection for its stabilization method. US11931458B2 (granted March 19, 2024) and US12409136B2 (granted September 9, 2025) protect the three-component stabilization architecture described in Section 4. These patents establish an independent technology moat

that is not replicable without licensing, and they document, in public patent record, that the problem of exosome stabilization has been specifically and inventively solved.

Competitors offering exosome products without equivalent patent protection have not established, and cannot establish, that their stabilization approach is independently novel, validated, or protected. The patent record is public and verifiable.

### *2. 24-Month Room-Temperature Stability, Independently Verified*

Exocellure is the only product in its category with a 24-month room-temperature stability study conducted by an independent accredited laboratory to United States Pharmacopeia pharmaceutical standards, across nine time points, with all results passing. This is not a manufacturer's claim. It is a third-party verified result that can be evaluated, audited, and compared against any competing claim.

The practical clinical significance is substantial: room-temperature stability eliminates cold chain dependency, reduces practitioner storage complexity, ensures that the product applied to the patient is the same product tested in the stability study, and provides a 24-month shelf life that enables professional ordering and stocking without wastage risk.

### *3. Verified Particle Integrity and Concentration*

NTA analysis confirming 134.6nm mean particle diameter, within the 30–160nm biologically active exosome range, and concentration at 2+ billion intact exosomes per mL in the final stabilized product provides practitioners with independently verified particle quality data. This data stands in direct contrast to competitor products for which no independent NTA verification has been published, and specifically against the competitor product confirmed at 10,283nm mean particle size by independent DLS analysis, a result that demonstrates the absence of biologically active exosomes.

Practitioners evaluating exosome products should request NTA or DLS particle size data from independent third-party laboratories for any product they consider using. The presence or absence of that data is a direct indicator of whether the manufacturer has verified what they are selling.

### *4. Confirmed Biological Cargo in Intact Exosomes*

ELISA confirmation of TGF-β1, BMP-2, and IL-10 in intact exosome preparations, not in lysed preparations or cell-conditioned media, verifies that the therapeutic cargo is packaged within the exosome membrane and available for intracellular delivery. This distinction is scientifically critical: conditioned media products, which constitute a significant portion of the aesthetic "exosome" market, deliver soluble cytokines but not encapsulated exosomal cargo. The mechanisms described in Section 6, intracellular TGF-β1/Smad signaling, miRNA-mediated regulation of collagen gene expression, require intact exosome delivery and cannot be reproduced by conditioned media preparations.

### *5. Canadian GMP Manufacturing*

Exocellure's product is manufactured under Canadian Good Manufacturing Practice standards, the same regulatory framework applied to licensed pharmaceutical products in Canada. GMP

manufacturing provides independent quality assurance of the manufacturing process, raw material sourcing, in-process testing, and release testing, a framework that goes beyond the quality requirements applicable to cosmetic or Class I medical device products. This manufacturing standard is verifiable and provides practitioners with confidence in the consistency and safety of every lot released to market.

### 8.2 The Competitive Comparison: An Objective Summary

| Evidence Criterion | Exocellure | Typical Competitor |
|---|---|---|
| Granted US Patent for stabilization | YES, US11931458B2 + US12409136B2 | None identified |
| Independent 24-month stability study | YES, 9 time points, USP standards, room temp | Not publicly available |
| Independent NTA particle size verification | YES, 134.6nm, ZetaView NTA | Not publicly available |
| Confirmed exosome concentration | YES, 2+ billion/mL in final product | Unverified or self-reported |
| Cargo confirmed in intact exosomes (ELISA) | YES, TGF-β1, BMP-2, IL-10 | Not demonstrated |
| Independent sterility testing (14-day) | YES, 3 reports, VRL Eurofins | Not publicly available |
| Endotoxin testing | YES, 0.134 EU/mL PASS | Not publicly available |
| Canadian GMP manufacturing | YES | Variable |
| Room-temperature liquid format | YES, stable 24 months | Typically refrigerated or lyophilized |
| Competitor product independently tested | YES, Jordi Labs DLS: 10,283nm | N/A |

*Table 5. Evidence-based competitive comparison, Exocellure vs. typical market competitor*

## 9. Conclusion

The science of MSC-derived exosome therapy is not emerging, it is established. The peer-reviewed literature, spanning more than a decade of research across multiple countries and research institutions, has produced a consistent and replicable body of evidence: Wharton's jelly MSCs are the optimal source, exosomes are the primary therapeutic vehicle within the MSC secretome, and the cargo delivered by UCMSC exosomes, TGF-β1, IL-10, BMP-2, fibronectin, and miRNA species including miR-125b-5p, acts through documented molecular mechanisms to suppress post-injury inflammation, direct collagen synthesis, and guide tissue toward organized, scar-free repair.

What has been missing, until now, is not the science. It is the technology. Lyophilization destroys exosome integrity. Ultra-cold storage requires an unbroken cold chain that the reality of clinical practice cannot guarantee. Unstabilized liquid preparations agglomerate: as the independent DLS testing of a leading competitor product confirmed, the particles that arrive at the practitioner's treatment table may be 68 times larger than the biologically active threshold, delivering no therapeutic benefit whatsoever.

Exocellure's patented three-component stabilization system solves this technology problem. The solution is independently verified, not by Exocellure, but by accredited commercial laboratories operating to United States Pharmacopeia pharmaceutical standards. The stability is confirmed across 24 months and nine time points. The particle integrity is confirmed at 134.6 nanometers by NTA using the same instrument used in published peer-reviewed exosome research. The biological cargo is confirmed in intact exosomes by ELISA. The sterility is confirmed across three independent 14-day tests. The endotoxin is confirmed below the acceptable threshold.

The clinical aesthetic literature now provides the human evidence that completes the translational chain: MSC exosomes delivered in the post-procedure window produce measurable, statistically significant improvements in texture, hydration, elasticity, pigmentation, scar volume, and recovery time, across randomized controlled trials, prospective split-face studies, and a systematic review spanning 15 years of published human data.

The conclusion is clear: Exocellure's technology is the only independently verified, patent-protected, room-temperature-stable liquid exosome system in the professional aesthetic market. It is the only product for which the gap between the published science and the clinical product has been demonstrably closed, by independent third-party evidence, by peer-reviewed scientific context, and by the granted patent record.

For the aesthetic practitioner seeking to integrate exosome therapy into their post-procedure protocols with the confidence that the biology described in the science literature is the biology that will arrive at their treatment table, the evidence presented in this white paper provides that foundation.

## References

All references below are cited in support of specific claims made in this white paper. Patent references are publicly accessible via the United States Patent and Trademark Office. Laboratory reports are proprietary documents held by Exocellure Dermaceuticals LLC. Peer-reviewed literature references are accessible through PubMed, Google Scholar, or the indicated journal.

## Patents and Patent Applications

**P1.** US11931458B2. Stabilized exosome composition and method of preparation. Filed January 10, 2022. Granted March 19, 2024. Anticipated expiration January 10, 2042. USPTO.

**P2.** US12409136B2. Stabilized exosome formulation with enhanced bilayer protection. Filed February 28, 2025. Granted September 9, 2025. USPTO.

**P3.** US Patent Application 20260000607. Polymer-polymer matrix architecture for exosome stabilization. Filed June 2025. Pending.

**P4.** US Patent Application 2016/0324794 A1 (Rion Health / Behfar et al.). Exosome preparations and therapeutic uses thereof. Published November 10, 2016. [Referenced as industry standard documentation for lyophilization and −80°C storage methods.]

## Independent Laboratory Reports

**L1.** Applied Consumer Services, Inc. Stability Study Report No. 41366/A. January 30, 2023. 24-month room-temperature stability evaluation of Exocellure EXO-V UltraLipid Exosome Recovery Serum. 9 time points. USP standards. Proprietary document, Exocellure Dermaceuticals LLC.

**L2.** DynaCord LLC / Zen-Bio. Certificate of Analysis. Lots #20210719 / #20210721. MSC-derived exosome source material characterization including NTA particle size (134.6nm), concentration (22.4B/mL pre-stabilization), ELISA confirmation of TGF-β1, BMP-2, IL-10, endotoxin, and sterility. Proprietary document, Exocellure Dermaceuticals LLC.

**L3.** VRL Eurofins. 14-Day Sterility Test Reports (×3 independent reports). Lot-specific sterility confirmation. Endotoxin: 0.134 EU/mL PASS. Proprietary documents, Exocellure Dermaceuticals LLC.

**L4.** Jordi Labs LLC. Dynamic Light Scattering Analysis. Job J21353-0. November 18, 2025. Elevai Exosome Regenerative Serum, Lot 25B07E1. Median particle size: 10,283.2nm; d10: 318.3nm; PI: 1.167. Proprietary document, Exocellure Dermaceuticals LLC.

## Peer-Reviewed Literature, Source Biology

**1.** Zeddou M, Briquet A, Relic B, Josse C, Malaise MG, Gothot A, Lechanteur C, Beguin Y. The umbilical cord matrix is a better source of mesenchymal stem cells (MSC) than the umbilical cord blood. Cell Biol Int. 2010;34(7):693–701. doi: 10.1042/CBI20090414.

**2.** Vangsness CT Jr, Sternberg H, Harris L. Umbilical cord tissue offers the greatest number of harvestable mesenchymal stem cells for research and clinical application: a literature review of different harvest sites. Arthroscopy. 2015 Sep;31(9):1836–43. doi: 10.1016/j.arthro.2015.03.014.

**3.** Manochantr S, U-pratya Y, Kheolamai P, Rojphisan S, Chayosumrit M, Tantrawatpan C, Supokawej A, Issaragrisil S. Immunosuppressive properties of mesenchymal stromal cells derived from amnion, placenta, Wharton's jelly and umbilical cord. Intern Med J. 2013 Apr;43(4):430–9. doi: 10.1111/imj.12044.

**4.** Udalamaththa VL, Kaluarachchi A, Wijeratne S, Udagama PV. Therapeutic uses of post-partum tissue-derived mesenchymal stromal cell secretome. Indian J Med Res. 2020 Dec;152:541–552. doi: 10.4103/ijmr.IJMR_1450_18.

**5.** Tsai SC, Yang KD, Chang KH, Lin FCF, Chou RH, Li MC, Cheng CC, Kao CY, Chen CP, Lin HC, Hsu YC. Umbilical cord mesenchymal stromal cell-derived exosomes rescue the loss of outer hair cells and repair cochlear damage in cisplatin-injected mice. Int J Mol Sci. 2021;22(13):6664. doi: 10.3390/ijms22136664.

## Peer-Reviewed Literature, Molecular Mechanisms


6. Saraiva M, Vieira P, O'Garra A. Biology and therapeutic potential of interleukin-10. J Exp Med. 2020 Jan 6;217(1):e20190418. doi: 10.1084/jem.20190418. PMC7037253.
7. Keswani SG, Balaji S, Le LD, Herber-Katz E. Regenerative wound healing: the role of interleukin-10. Adv Wound Care. 2014;3(4):315–323. doi: 10.1089/wound.2012.0401. PMC3985521.
8. Ting-Ting Wang et al. The role of the anti-inflammatory cytokine interleukin-10 in tissue fibrosis. Adv Wound Care. 2020;9(4):184–198. doi: 10.1089/wound.2019.1032. PMC7047112.
9. Hu G et al. Human umbilical cord mesenchymal stem cell exosomes promote elastin production and acute skin wound healing via TGFβ1-Smad pathway. Mol Cell Biochem. 2025. doi: 10.1007/s11010-025-05264-5.
10. Liu Z, et al. MSC-EVs and UCB-EVs promote skin wound healing and spatial transcriptome analysis. Sci Rep. 2025;15. doi: 10.1038/s41598-025-87592-6.
11. Wang Y, et al. Human hair follicle mesenchymal stem cell-derived exosomes attenuate UVB-induced photoaging via the miR-125b-5p/TGF-β1/Smad axis. Biomater Res. 2024. doi: 10.34133/bmr.0121.
12. Zhang Y, et al. MSC-derived exosomes: A novel agent for skin aging treatment. Biomed Res Ther. 2024;11. doi: 10.15419/bmrat.v11i12.946.
13. Zhu L, et al. Bioengineered MSC-derived exosomes in skin wound repair and regeneration. Front Cell Dev Biol. 2023. doi: 10.3389/fcell.2023.1029671. PMC10009159.


## Peer-Reviewed Literature, Clinical Aesthetic Evidence


14. Park GH, Kwon HH, Seok J, Yang SH, Lee J, Park BC, Shin E, Park KY. Efficacy of combined treatment with human adipose tissue stem cell-derived exosome-containing solution and microneedling for facial skin aging: a 12-week prospective, randomized, split-face study. J Cosmet Dermatol. 2023;22(12):3418–3426. doi: 10.1111/jocd.15849.
15. Kwon HH, et al. Comparison and analysis of adipose-derived exosomes applied with fractional CO2 laser. Dermatol Surg. 2020.
16. Vitale M, Ruri P, Marini S, Zappia E, Yi KH. Clinical outcomes of exosome-augmented microneedling and laser therapies in full-face skin rejuvenation: a split-face observational study. J Craniofac Surg. 2025. doi: 10.1097/SCS.0000000000011807.
17. Peredo MI, Shivananjappa S. Topical human MSC-derived exosomes for wound healing after aesthetic procedures: a case series. J Drugs Dermatol. 2024;23:281–284.
18. Proietti I, Battilotti C, Svara F, et al. Efficacy and tolerability of a microneedling device plus exosomes for treating melasma. Appl Sci. 2024;14(16):7252. doi: 10.3390/app14167252.
19. Chernoff G. The utilization of human placental fetal MSC-derived exosomes in treating keloid scars. J Surg. 2022;7:1482.
20. Lee KW, Abosalha A, et al. The efficacy of MSC-derived exosome-based therapies in treating scars, aging and hyperpigmentation: a systematic review of human clinical outcomes. Cosmetics. 2025;8(4):268. doi: 10.3390/cosmetics8040268.
21. Lee M, Park G, et al. Efficacy of combined exosome (Exodew) and microneedling treatment for facial pore reduction and skin texture improvement. PMC12140750. 2024.

Exocellure EXO-V UltraLipid Exosome Recovery Serum is a professional cosmetic product formulated for use as a microneedling glide medium. It is not an FDA-regulated drug or biologics product. No drug claims are made in this document. Claims are limited to cosmetic territory as defined under 21 CFR Parts 700–740.

Patent markings: Patent Nos.: US11931458B2 · US12409136B2 · Additional patents pending. Virtual patent marking: exocellure.com/patents.