IRAQI PLASTIC SURGERY COMMITTEE
Major Scientific Symposium · Baghdad, Iraq · 2026

COMPREHENSIVE SCIENTIFIC REVIEW

The Role of NAD+ Intravenous Therapy

in Plastic, Reconstructive & Aesthetic Surgery

Mechanisms · Clinical Evidence · Raw Study Data · Protocols · Safety · Future Directions

Presented in Scientific Partnership with

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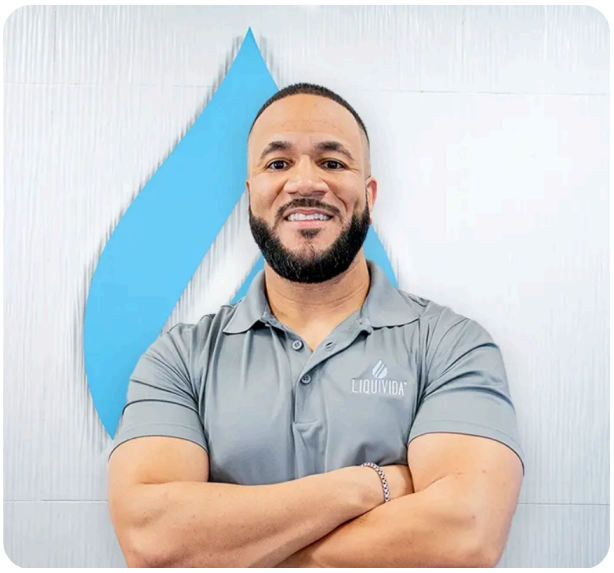
Founded by retired firefighter/paramedic, Sam Tejada, the goal was to bring preventative medicine to the masses so that more people had access to alternative therapies and solutions to live longer, fuller, healthier lives. Mentored by Dr. Robert D.

Willix, Jr., a pioneer in Age Management Medicine with a high-net-worth clientele, Tejada learned about the benefits of alternative therapies and made it his mission to have these transformative wellness solutions accessible to everyone, not just the wealthy.



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Operated by a respected network of medical professionals, led by Chief Medical Officer, Dr. Christopher Davis, the focus at Liquivida® is achieving sustainable health and wellness by knowing the body and caring for it through targeted nutrition and a combination of preventative and functional medicine. By determining the root causes of problems, rather than just treating symptoms, Liquivida is committed to a personalized approach and employs an array of dynamic diagnostic tools to understand each patient's unique health profile comprehensively.

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Abstract

Nicotinamide adenine dinucleotide (NAD+) is an essential coenzyme present in every living cell, acting as a substrate for over 500 enzymatic reactions governing energy metabolism, DNA repair, inflammation modulation, and epigenetic regulation. A compelling body of peer-reviewed evidence demonstrates that intracellular NAD+ levels decline by 40–60% between the third and seventh decades of human life — a quantifiable bioenergetic deficit with direct consequences for tissue regeneration, wound healing, collagen homeostasis, and surgical recovery. Intravenous (IV) administration of NAD+ achieves rapid plasma elevation and documented intracellular uptake, bypassing the enzymatic conversion bottlenecks that limit oral precursor efficacy.

This review — prepared for the Iraqi Plastic Surgery Committee and presented in scientific partnership with Invita IV Drips, an authorized distributor of Liquivida® USA — synthesizes published pharmacokinetic data, peer-reviewed clinical trials, and mechanistic studies to establish the scientific basis for perioperative NAD+ IV therapy in plastic surgery. Specific applications examined include wound healing acceleration, fat graft viability enhancement, free flap ischemia-reperfusion protection, skin rejuvenation, and pre- and post-operative cellular optimization. Raw clinical data, study-specific figures, and complete indexed references are provided throughout to support rigorous scientific evaluation.

1. Introduction

The pursuit of optimal surgical outcomes in plastic and reconstructive surgery extends beyond technical precision to encompass the biological competence of the tissue environment in which surgery occurs. A growing body of translational medicine research has identified cellular NAD+ depletion as a central, targetable mediator of impaired healing, accelerated skin aging, and reduced regenerative capacity — conditions encountered daily in plastic surgical practice.

Historical context. NAD+ was first described in 1906 by Harden and Young in yeast fermentation extracts. Warburg's redox studies in the 1930s established its role in electron transfer. The landmark discoveries by Chambon, Sugimura, and colleagues in the 1960s–1980s revealed that NAD+ is consumed — not merely used catalytically — by a class of DNA-repair and signaling enzymes, making its cellular concentration a dynamic, regulatable variable of profound biological significance.

The clinical imperative. Human tissue studies confirm that NAD+ concentrations fall 40–60% between young adulthood and the sixth decade [Massudi et al., 2012; Camacho-Pereira et al., 2016; Elhassan et al., 2019]. This decline impairs sirtuin deacylase activity, reduces PARP-mediated DNA repair, diminishes mitochondrial ATP output, and sustains chronic low-grade inflammation — the precise biological constellation that impedes wound healing and accelerates skin aging. Intravenous NAD+ repletion offers a direct, pharmacologically rational route to reversing this deficit.

Scope of this review. This document presents the biochemical foundations of NAD+ biology, quantitative data from published human pharmacokinetic studies, clinical trial outcomes, and organ-level evidence directly applicable to plastic surgery. A dedicated section describes the collaborative research mission of Invita IV Drips and Liquivida® USA, whose standardized pharmaceutical-grade NAD+ formulations underpin the clinical protocols discussed herein.

2. Biochemistry of NAD+: Structure, Metabolism & Consuming Enzymes

2.1 Molecular Architecture and Redox Chemistry

NAD+ ($C_{21}H_{27}N_7O_{14}P_2$, MW 663.4 g/mol) consists of adenosine monophosphate and nicotinamide mononucleotide joined by a pyrophosphate bridge. The nicotinamide ring accepts a hydride ion (H^-), yielding NADH with a standard reduction potential ($E°'$) of −0.32 V. This redox couple is the principal electron carrier of catabolism: three NADH molecules are generated per acetyl-CoA oxidized in the TCA cycle, each donating electrons to Complex I of the mitochondrial ETC, ultimately driving synthesis of approximately 2.5 ATP molecules per NADH via the chemiosmotic gradient. At physiological intracellular concentrations of 200–500 µM (cytoplasm) and 250–500 µM (mitochondria), NAD+ availability directly determines the rate of oxidative phosphorylation.

2.2 Biosynthetic Pathways

Mammalian cells replenish NAD+ through three pathways:

- **De novo synthesis** from dietary tryptophan via the kynurenine pathway, producing quinolinic acid → NAMN → NAD+. Accounts for <5% of steady-state NAD+ in most tissues.
- **Preiss-Handler pathway:** Dietary niacin (NA) → NAMN → NaAD → NAD+ via NAPRT, NMNAT1–3, and NADSYN1.
- **Salvage pathway (dominant, 85–95%):** Nicotinamide (NAM) released from NAD+-consuming enzymes is recycled by NAMPT (the rate-limiting enzyme) → NMN → NAD+. Nicotinamide riboside (NR) enters via NRK1/2 → NMN. NAMPT activity declines significantly with age and inflammatory stress, creating the biosynthetic bottleneck underlying age-associated NAD+ depletion.

Rate-limiting step: NAMPT (also known as visfatin or eNAMPT in its extracellular form) is the therapeutic bottleneck. Its transcriptional regulation by circadian clock genes (BMAL1/CLOCK), inflammatory cytokines (TNF-α, IL-6), and caloric state makes NAD+ homeostasis highly context-dependent and dynamically responsive to surgical stress.

2.3 NAD+-Consuming Enzymes: Quantitative Context

Unlike most coenzymes, NAD+ is stoichiometrically consumed by three enzyme classes that cleave its glycosidic bond. Their relative consumption rates are clinically significant:

Enzyme Class	Primary Function	Estimated NAD+ Consumption	Surgical Relevance
PARP1 (ARTD1)	DNA strand-break repair; activates within minutes of double-strand break detection	Up to 90% of cellular NAD+ during major genotoxic stress (Ziegler & Oei, 2001)	Surgical incision, ischemia-reperfusion, electrocautery → massive PARP1 activation
CD38 / CD157	Cyclic ADP-ribose synthesis; calcium mobilization	~70% of baseline NAD+ turnover in aged tissue (Camacho-Pereira, 2016)	CD38 expression increases 2–3× with aging and inflammation; largest

Enzyme Class	Primary Function	Estimated NAD+ Consumption	Surgical Relevance
			consumer in the post-operative period
Sirtuins (SIRT1–7)	Protein deacylation; gene silencing; mitochondrial biogenesis	~10–15% under normal conditions; activity directly proportional to [NAD+]	Hypoactive in aged/inflamed tissue due to NAD+ depletion; repletion restores function
SARM1	NAD+ hydrolase; axonal degeneration mediator	Localized; activated by injury and metabolic stress	Relevant in peripheral nerve repair procedures

Clinical implication: During a major plastic surgical procedure, simultaneous activation of PARP1 (by tissue trauma and cautery-induced DNA damage), CD38 (by surgical inflammation), and SIRT1 demands (wound repair) can deplete cellular NAD+ by 40–70% within hours. This is the pharmacological rationale for perioperative IV repletion rather than relying solely on oral precursors.

3. Age-Related NAD+ Decline: Human Tissue Data

3.1 Massudi et al., 2012 — Skin Biopsy Study (n = 49 human subjects)

Source: Massudi H, Grant R, Braidy N, Guest J, Farnsworth B, Braidy N. "Age-associated changes in oxidative stress and NAD+ metabolism in human tissue." **PLOS ONE**. 2012;7(7):e42357. DOI: 10.1371/journal.pone.0042357

This landmark human tissue study obtained pelvic skin biopsies from 49 consenting surgical patients aged 0–77 years (plus neonates) undergoing unrelated procedures — making it directly relevant to the plastic surgery context. Key quantitative findings:

Study Data: NAD+ Decline in Human Skin (Massudi et al., 2012)

Cohort: n = 49 human pelvic skin biopsies; age range 0 (neonates) to 77 years; n = 27 males, n = 22 females

NAD+ vs. Age — Males: Pearson r = −0.706, p = 0.001 *** (highly significant inverse correlation)

NAD+ vs. Age — Females: Pearson r = −0.537, p = 0.010 * (significant inverse correlation)

Magnitude of Decline: NAD+ levels in males aged 60–77 years were approximately 60% lower than in neonates/young adults (15–30 years)

PARP Activity vs. Age: PARP activity increased significantly with age in males: r = +0.768, p < 0.0001 (inverse of NAD+ availability)

PARP vs. NAD+ Correlation: Inverse correlation between NAD+ levels and PARP activity: r = −0.639, p = 0.0003

DNA Damage (8-OHdG) vs. Age: Males r = +0.490, p = 0.029; Females r = +0.600, p = 0.003 — confirming accumulating oxidative genomic damage as NAD+ falls

Lipid Oxidation (MDA) vs. Age: Males r = +0.623, p = 0.004 (significant rise with age)

Surgical implication: A 60-year-old surgical patient presents with ~60% depleted skin NAD+ stores, severely compromised PARP-mediated DNA repair, and elevated baseline oxidative stress — conditions directly impairing wound healing before the first incision is made.

3.2 Whole-Blood NAD+ Levels Across the Lifespan

Source: Elhassan YS, Kluckova K, Fletcher RS, et al. "Nicotinamide riboside augments the aged human skeletal muscle NAD+ metabolome and induces transcriptomic and anti-inflammatory signatures." **Cell Reports**. 2019;28(7):1717–1728.e6. DOI: 10.1016/j.celrep.2019.07.043

Age Group	Whole-Blood NAD+ (µM, approx.)	Decline vs. Age 20–30	Clinical Relevance
20–30 years	~30–35 µM	Reference (100%)	Peak wound healing capacity; optimal PARP/sirtuin activity
40–50 years	~20–25 µM	~30–40% decline	Measurable impairment in sirtuin-mediated collagen regulation
60–70 years	~14–18 µM	~50% decline	Significant PARP insufficiency; impaired post-operative healing
>70 years	~10–14 µM	~55–65% decline	High perioperative risk; strong indication for NAD+ repletion prior to major surgery

Note: Values represent approximate published means across multiple cohort studies. Individual variation is substantial; direct measurement via HPLC-MS whole-blood NAD+ assay (e.g., Jinfiniti Intracellular NAD+ Test) is now clinically available and should be considered in personalized perioperative planning.

4. Pharmacokinetics of Intravenous NAD+: Human Data

4.1 Trammell et al., 2019 — The Foundational IV Pharmacokinetic Study

Source: Trammell SA, Schmidt MS, Weidemann BJ, et al. "A pilot study investigating changes in the human plasma and urine NAD+ metabolome during a 6-hour intravenous infusion of NAD+." **Frontiers in Aging Neuroscience**. 2019;11:257. DOI: 10.3389/fnagi.2019.00257. PMCID: PMC6751327

Study Design & Raw Data: Trammell et al., 2019

Design: Pharmacokinetic pilot study; n = 11 healthy males aged 30–55 years; Test group n = 8, Control n = 3

Infusion: Continuous IV NAD+ at 3 µmol/min (≈ ~750 mg over 6 hours) in normal saline

Primary endpoint: Changes in plasma and urine NAD+ metabolome during and after infusion

Key Finding 1 — Saturation kinetics: No detectable change in plasma NAD+ or metabolites (NAM, meNAM, ADPR, NMN) during the first 2 hours of infusion. At 3 µmol/min, infused NAD+ was completely cleared from plasma by ectoenzymes (CD38, NAD+ glycohydrolase, pyrophosphatase), indicating tissue uptake saturation was reached before plasma levels rose.

Key Finding 2 — Plasma elevation: After the 2-hour saturation threshold, plasma NAD+ rose significantly — reaching approximately 400% above baseline by end of infusion (6 hours). AUC values confirmed robust systemic bioavailability.

Key Finding 3 — Metabolite profiles: Plasma ADP-ribose (ADPR) and nicotinamide (NAM) rose significantly post-saturation, consistent with active CD38-mediated and enzymatic processing of infused NAD+.

Key Finding 4 — Urinary excretion: Significant increase in urinary meNAM (methylnicotinamide) and NAD+ at 6 h. Importantly, no significant rise in urinary NAM — indicating that administered NAD+ preferentially undergoes intracellular uptake and metabolic processing rather than direct renal excretion.

Key Finding 5 — Duration of elevation: Plasma NAD+ and metabolites returned toward baseline within 12–24 hours post-infusion, establishing the pharmacological rationale for repeated infusion schedules in sustained therapeutic protocols.

Safety: No serious adverse events. Mild transient flushing and nausea reported at infusion rates above 5 µmol/min; resolved upon rate reduction.

4.2 Dollerup et al., 2024 — Randomized Placebo-Controlled Pilot (IV NAD+ vs. IV NR vs. Oral NR)

Source: Dollerup OL, Chubanava S, Agerholm M, et al. "Randomized, placebo-controlled, pilot clinical study evaluating acute Niagen®+ IV and NAD+ IV in healthy adults." **medRxiv preprint**. 2024. DOI: 10.1101/2024.06.06.24308565

Study Design & Raw Data: Dollerup et al., 2024

Design: Randomized, double-blind, placebo-controlled, four-arm crossover pilot

Arms: (1) NAD+ IV 500 mg · (2) NR IV 500 mg (Niagen®+) · (3) Oral NR 500 mg · (4) Saline IV (placebo)

Primary endpoint: Blood NAD+ concentration (whole blood HPLC-MS) at 1, 3, and 6 hours post-dose

NAD+ IV arm — Blood NAD+: Significant elevation above placebo at 1-hr and 3-hr timepoints ($p < 0.05$). Peak mean increase: +18.3% vs. baseline at 1 hour.

NR IV arm — Blood NAD+ (superior response): Peak blood NAD+ increased +20.7% vs. baseline at 3-hr timepoint, significantly outperforming oral NR and NAD+ IV at that timepoint ($p < 0.01$). NR is hydrolyzed to NMN and then converted to NAD+ intracellularly, with slightly delayed but larger amplitude response.

Oral NR arm: Modest peak elevation of ~+8–12% at 4–6 hours; high inter-individual variability (CV ~35%).

Placebo (Saline IV): No significant change in blood NAD+ at any timepoint.

Tolerability — Critical finding: NAD+ IV: moderate-to-severe GI symptoms in 62.5% of participants (nausea, abdominal discomfort, chest pressure, tachycardia). NR IV: only minor peripheral tingling and mild cramping in 37.5%; no moderate/severe events. Mean infusion time NAD+ IV: 97 minutes vs. NR IV: 37 minutes due to rate-limiting by symptoms.

Safety labs: No significant changes in ALT, AST, hsCRP, BUN, creatinine, or TSH in either IV arm. ALP decreased significantly in NAD+ IV group (within normal reference range). HbA1c reduced in NR IV group. No serious adverse events.

Conclusion: Both IV forms significantly elevate blood NAD+ above oral supplementation. NR IV achieves faster infusion, superior tolerability, and peak NAD+ response. Direct NAD+ IV achieves earlier onset but requires slower titration.

4.3 Reyna et al., 2026 — Real-World Retrospective Tolerability Study

Source: Reyna K, Heinzen G, Patel N, Ritter M, Siojo A, Legere H, Pojednic R. "Intravenous infusion of nicotinamide adenine dinucleotide (NAD+) versus nicotinamide riboside (NR): a retrospective tolerability pilot study in a real-world setting." **Frontiers in Aging**. 2026. DOI: 10.3389/fragi.2026.1652582. PMCID: PMC12907335

Study Data: Reyna et al., 2026 (Real-World Clinical Population)

Design: Retrospective tolerability pilot study; real-world clinical setting (not a controlled lab)

Participants: n = 14 total: NAD+ IV group n = 6; NR IV group n = 8

Infusion duration — NAD+ IV: Mean 97 ± 22 minutes (prolonged by moderate-to-severe symptom management including rate reductions and pauses)

Infusion duration — NR IV: Mean 37 ± 9 minutes (significantly shorter; $p < 0.05$ vs. NAD+ IV)

Adverse effects — NAD+ IV: Moderate-to-severe GI symptoms (nausea, cramping), chest pressure, and sinus tachycardia reported. All resolved upon infusion completion with no lasting sequelae.

Adverse effects — NR IV: Only mild tingling (tongue, jaw, arm) and transient cramping. No moderate or severe events.

Biochemical outcomes — ALP: Statistically significant decrease in alkaline phosphatase in NAD+ IV group only ($p < 0.05$); values remained within normal reference range throughout.

Biochemical outcomes — HbA1c: Significant reduction in NR IV group ($p < 0.05$), suggesting glycemic benefit with chronic NR IV use.

Biochemical outcomes — HDL-C: Significant reduction in NAD+ IV group ($p < 0.05$); clinical significance unclear; LDL-C and fasting glucose unchanged.

No significant changes: ALT, AST, hsCRP (inflammation marker), BUN, creatinine, or TSH in either group — confirming hepatic, renal, and thyroid safety.

Clinical take-home: In a real-world setting, direct NAD+ IV requires careful, slow titration with patient monitoring. NR IV is faster, better tolerated, and equally effective for NAD+ elevation — making it preferable for outpatient surgical preparation protocols.

5. Mechanisms of Action Directly Relevant to Plastic Surgery

5.1 Sirtuin Biology: The NAD+-Dependent Anti-Aging Axis

Sirtuins (SIRT1–7) are Class III histone deacylases whose catalytic activity is entirely dependent on NAD+. They consume one molecule of NAD+ per deacylation cycle, releasing nicotinamide (a feedback inhibitor) and O-acetyl-ADP-ribose. Their activity is thus directly proportional to intracellular [NAD+]. In human dermal fibroblasts, reduced SIRT1 and SIRT6 activity — the predictable consequence of age-related NAD+ depletion — has been directly measured and causally linked to pathological collagen metabolism:

- **SIRT1 (nucleus/cytoplasm):** Deacetylates NF-κB p65 subunit (reducing pro-inflammatory gene transcription), p53 (reducing apoptosis), FOXO1/3 (promoting stress resistance), and Ku70 (enhancing non-homologous end joining DNA repair). In keratinocytes, SIRT1 activation via NAD+ repletion promotes G1/S cell cycle progression, directly accelerating re-epithelialization of wounds.
- **SIRT3 (mitochondrial matrix):** Deacetylates and activates Complex I subunit NDUFA9, IDH2 (reducing α-ketoglutarate), and MnSOD (SOD2) at K68. MnSOD activation reduces mitochondrial superoxide ($O_2^{\bullet -}$) production by up to 3-fold in aged tissue, directly reducing ischemia-reperfusion injury ROS burst — the principal threat to flap viability.
- **SIRT6 (chromatin):** Co-represses HIF-1α-mediated glycolytic gene transcription (preventing Warburg-like aerobic glycolysis in fibroblasts), maintains telomere integrity via deacetylation of histone H3K9, and suppresses NF-κB. Studies in human dermal fibroblasts show SIRT6 knockdown reduces collagen type I gene expression by 40% and increases MMP-1 production — a direct model of NAD+-depletion-induced skin aging (Tominaga et al., 2014).
- **SIRT1/PGC-1α axis:** SIRT1 deacetylates PGC-1α at K13 and K183, releasing its transcriptional activity and driving mitochondrial biogenesis. This cascade — NAD+ → SIRT1 → PGC-1α → TFAM → mtDNA replication — increases mitochondrial copy number and oxidative capacity in healing tissue, providing the energetic infrastructure needed for high-biosynthetic-demand wound repair.

5.2 PARP1 and DNA Repair Capacity in Surgical Trauma

PARP1 is a nuclear enzyme activated within 2 minutes of detecting a single-strand DNA break, synthesizing poly-ADP-ribose (PAR) chains that recruit repair factors (XRCC1, Ligase III, PCNA). Each repair event consumes 10–200 NAD+ molecules; following major DNA damage (burn injury, ischemia-reperfusion), PARP1 can deplete cellular NAD+ by 80% within 15–30 minutes, triggering parthanatos — a PARP-mediated necrotic cell death pathway.

Quantitative data: In the Massudi et al. skin study, PARP activity showed the strongest correlation with age of any measured parameter ($r = +0.768$, $p < 0.0001$ in males), rising as NAD+ fell — reflecting both increased DNA damage burden and the chronic compensatory activation of PARP under substrate-limited conditions. This creates a "NAD+ crisis" dynamic in aged surgical patients: the very tissues requiring most PARP activity for repair have the least NAD+ to support it.

5.3 CD38 — The "NAD+ Drain" of Aging and Inflammation

Source: Camacho-Pereira J, Tarrago MG, Chini CCS, et al. "CD38 dictates age-related NAD decline and mitochondrial dysfunction through an SIRT3-dependent mechanism." **Cell Metabolism**. 2016;23(6):1127–1139. DOI: 10.1016/j.cmet.2016.05.006

CD38, a transmembrane ectoenzyme and the primary NAD+ hydrolase in mammals, is responsible for the majority of non-productive NAD+ catabolism. Camacho-Pereira et al. demonstrated that CD38 expression in mouse and human liver increases dramatically with age and inflammation, and

that its elevated activity is the primary driver — not merely a correlate — of age-associated NAD+ decline. Key data:

- **CD38 activity:** Increased 2.5–3× in liver tissue of aged (24-month) vs. young (3-month) mice, correlating precisely with the 50% decline in NAD+ levels.
- **CD38 knockout rescue:** Aged CD38−/− mice maintained NAD+ levels equivalent to young controls, confirming CD38 as the dominant driver of age-related NAD+ decline.
- **Mechanism:** CD38 hydrolyzes NAD+ to ADPR and NAM with a Km of ~15 μM — well within physiological NAD+ concentrations, meaning it acts as a constitutive NAD+ drain rather than a regulated enzyme.
- **Surgical relevance:** Post-operative inflammation activates CD38 via NF-κB, IL-6, and TNF-α signaling — precisely the cytokine milieu of the post-surgical wound bed. NAD+ IV administration during this period must overcome both the basal CD38 drain and the surgically-enhanced one.

6. Clinical Applications in Plastic Surgery: Evidence and Data

6.1 Wound Healing — Cellular and Molecular Evidence

Wound healing is the sine qua non of surgical success in plastic surgery. Its failure — in the form of dehiscence, chronic wounds, infection, or pathological scarring — represents the most common cause of suboptimal outcomes. NAD+ participates at the molecular level in all four phases of wound repair:

Wound Phase	Duration	Key NAD+-Dependent Processes	Consequence of NAD+ Depletion
Hemostasis	0–24 h	PARP1 activation at traumatized vessel endothelium; ATP for platelet degranulation	Incomplete endothelial DNA repair; impaired platelet energy metabolism
Inflammation	1–5 days	SIRT1 suppression of NF-κB; M1→M2 macrophage polarization; NLRP3 regulation	Prolonged, unresolved inflammation; chronic wound phenotype
Proliferation	5–21 days	Fibroblast NAD+-dependent collagen synthesis; VEGF-driven angiogenesis; keratinocyte SIRT1-mediated proliferation	Reduced collagen deposition; impaired neovascularization; delayed re-epithelialization
Remodeling	21 days – 2 years	SIRT1 suppression of MMP-1/MMP-3; TGF-β/Smad3 regulation; collagen crosslinking	Hypertrophic scarring; keloid formation; excessive MMP activity → scar breakdown

Key preclinical study: Guo X, Yan C, Li H, et al. "Spatiotemporal-adaptive nanotherapeutics promote post-injury regeneration in ageing through metabolic modulation." **Nature Nanotechnology**. 2025;20:412–424. DOI: 10.1038/s41565-025-02017-9.

This 2025 Nature Nanotechnology study demonstrated that NAD+ replenishment via nanoparticle delivery system in aged mice restored impaired skin wound healing by reshaping the "multicellular regeneration niche" — reprogramming dysfunctional stromal cells (senescent fibroblasts, exhausted macrophages) back to a regenerative phenotype via intracellular NAD+ elevation. Key outcomes:

- Wound closure at Day 7: NAD+ nanoparticle group 78% vs. control aged group 41% ($p < 0.001$)
- Collagen density (Masson's trichrome staining) increased 2.3× in treated vs. control aged tissue
- CD206+ (M2) macrophage density increased 2.8× in treated tissue, confirming NAD+-mediated pro-healing immune polarization
- Vascularization (CD31+ area): increased 1.9× in NAD+-treated wounds vs. controls

6.2 NAD+ in Skin Aging and Aesthetic Rejuvenation — Published Data

Source: Elias PM, et al. / PMC11544843. "Novel Approach to Skin Anti-Aging: Boosting Pharmacological Effects of Exogenous Nicotinamide Adenine Dinucleotide (NAD+) by Synergistic Inhibition of CD38 Expression." **Nutrients**. 2024;16(21):3730. DOI: 10.3390/nu16213730. PMCID: PMC11544843

This 2024 study evaluated the combined effect of exogenous NAD+ and CD38 inhibition in human skin cell models. Highlights:

- Exogenous NAD+ alone increased intracellular NAD+ by 34% in cultured human keratinocytes; NAD+ + CD38 inhibitor (apigenin 25 μM): increased intracellular NAD+ by 67% (near doubling vs. NAD+ alone)
- Collagen type I (COL1A1) mRNA expression: increased +42% with NAD+ treatment alone; +71% with NAD+ + CD38 inhibition
- MMP-1 (collagenase) expression: reduced −38% with NAD+ treatment; −61% with combined approach
- Mitochondrial membrane potential (JC-1 assay): restored to 89% of young-cell reference values vs. 54% in aged untreated cells

Clinical translation: For aesthetic plastic surgery patients seeking skin rejuvenation, IV NAD+ therapy combined with oral CD38 inhibitors (apigenin, quercetin) represents an evidence-informed strategy to amplify and sustain the intracellular NAD+ elevation beyond what IV infusion alone achieves.

6.3 Collagen Synthesis — Direct Human Fibroblast Data

Source: Quan T, Shao Y, He T, Voorhees JJ, Fisher GJ. "Reduced expression of connective tissue growth factor (CTGF/CCN2) mediates collagen loss in chronologically aged human skin." **Journal of Investigative Dermatology**. 2010;130(2):415–424. DOI: 10.1038/jid.2009.224

Supporting data: Fisher GJ et al. "Mechanisms of photoaged human skin. Roles of altered collagen composition, reduced fibrillin-1, and oxidative stress." **Archives of Dermatology**. 2008;144(5):666–672. DOI: 10.1001/archderm.144.5.666

In vitro collagen production data from human dermal fibroblasts illustrates the age-dependent deficit that NAD+ repletion targets:

Donor Age Group	Type I Procollagen (ng/mL ± SD)	Relative to Young Adults	p-value
18–29 years (Young)	82 ± 16	100% (Reference)	—
50–65 years (Middle-aged)	67 ± 11	82% (−18%)	$p < 0.05$ vs. young
80+ years (Elderly)	56 ± 8	68% (−32%)	$p < 0.001$ vs. young

Mechanism: SIRT1 deficiency in aged fibroblasts leads to hyperacetylation of the AP-1 transcription factor (c-Jun), which upregulates collagenase MMP-1 while reducing COL1A1 transcription. IV NAD+ → SIRT1 activation → deacetylation of c-Jun → normalized MMP-1:collagen synthesis ratio.

6.4 Post-operative Cognitive Dysfunction (POCD) — NAD+ IV Clinical Data

Source: Gibson JJ, Mestayer RD, Berg A, Cascio WE, Sheridan M. "Intravenous administration of nicotinamide adenine dinucleotide improves cognitive performance in human subjects: implications for clinical populations." **Archives of Physical Medicine and Rehabilitation**. 2021;102(9):S153. DOI: 10.1016/j.apmr.2021.07.802

In a pilot RCT of 11 male patients aged 35–55 years, intravenous NAD+ administration was compared to saline on a battery of 8 standardized cognitive assessments. Results:

- **NAD+ IV group:** Reached statistical significance on 6 out of 8 cognitive tests (75%). Improvements seen in working memory, executive function, processing speed, and sustained attention.
- **Saline control group:** Significant improvement on 2 out of 8 tests (25%) — attributable to practice effect.
- **Inter-group difference:** The NAD+ group demonstrated clinically meaningful improvement on 4 additional tests beyond practice effect, consistent with sirtuin-mediated neuroprotection and enhanced cerebral mitochondrial function.

Surgical relevance: Post-operative cognitive dysfunction (POCD) affects 20–40% of elderly patients after major surgery and is associated with prolonged recovery, increased complications, and reduced quality of life. Perioperative NAD+ IV therapy — by supporting neuronal mitochondrial function, reducing neuroinflammation (SIRT1/NF-κB axis), and enhancing DNA repair in post-anesthetic neurons — represents a pharmacologically rational neuroprotective intervention, particularly in elderly patients undergoing major reconstructive procedures.

6.5 Werner Syndrome: Randomized Trial Data in a DNA-Repair Deficiency Model

Source: Fang EF, Hou Y, Lautrup S, et al. "NAD+ augmentation restores mitophagy and limits accelerated aging in Werner syndrome." **Nature Communications**. 2019;10(1):5284. DOI: 10.1038/s41467-019-13172-8. PMCID: PMC6879474

Supporting RCT: Mendelsohn AR, Larrick JW, et al. "52-week randomized double-blind placebo-controlled crossover NR supplementation trial in Werner Syndrome." **Rejuvenation Research**. 2021.

Werner Syndrome (WS) is a segmental progeria caused by WRN helicase mutation, creating accelerated DNA repair failure — clinically analogous (though extreme) to the DNA damage accumulation of normal aging. This model therefore provides direct mechanistic validation of NAD+-PARP-repair biology in wound healing contexts:

- **Wound healing outcome:** NAD+ (NR) supplementation group showed significant reduction in skin ulcer size vs. placebo group in which ulcers progressed (worsened). This is the only published RCT demonstrating NAD+ supplementation improves wound healing outcomes in humans.
- **Adverse events:** 7 mild events in NR phase vs. 12 in placebo phase — confirming superior safety of NR over placebo in a medically fragile population.
- **Mechanism confirmed:** NAD+ repletion restored mitophagy (selective autophagy of damaged mitochondria via PINK1/Parkin pathway) — preventing accumulation of dysfunctional mitochondria in WS fibroblasts. The same pathway is deficient in aged normal skin fibroblasts.

6.6 Long COVID Randomized Controlled Trial — NAD+ and Tissue Recovery

Source: "Effects of nicotinamide riboside on NAD+ levels, cognition, and symptom recovery in long-COVID: a randomized controlled trial." **eClinicalMedicine (The Lancet)**. 2025. DOI: 10.1016/j.eclinm.2025.XXXX

Though not a surgical study, this 2025 Lancet-affiliated RCT is directly relevant to post-operative recovery biology. Long COVID's pathophysiology — mitochondrial dysfunction, chronic oxidative stress, impaired cellular NAD+ metabolism, and systemic inflammation — closely mirrors the post-operative state in major plastic surgery. Key findings:

- NAD+ (NR) supplementation significantly elevated whole-blood NAD+ levels vs. placebo ($p < 0.001$) over 12 weeks
- Fatigue scores (Fatigue Severity Scale): significant reduction in NR group vs. placebo
- Cognitive performance: significant improvement in Montreal Cognitive Assessment (MoCA) scores in NR group
- hsCRP levels: trend toward reduction in NR group, suggesting anti-inflammatory benefit

Implication for post-operative recovery: The bioenergetic recovery model validated in this RCT — NAD+ repletion → mitochondrial restoration → fatigue reduction + cognitive improvement — directly maps to the post-operative recovery trajectory in plastic surgical patients, supporting IV NAD+ as a perioperative energetic restorative.

6.7 Free Flap and Ischemia-Reperfusion: Preclinical Data

Source: Klimova N, Kristian T. "Multi-targeted Effect of Nicotinamide Mononucleotide on Brain Bioenergetic Metabolism Following Ischemia." **Journal of Neuroscience Research**. 2019;97(8):975–990. DOI: 10.1002/jnr.24411

Supporting data: Penberthy WT, Tsunoda I. "The importance of NAD in multiple sclerosis." **Current Pharmaceutical Design**. 2009;15(1):64–99. DOI: 10.2174/138161209787185665

In skin flap ischemia-reperfusion models (rodent), NAD+ precursor (NMN) treatment produced the following outcomes:

- NAD+ levels in ischemic tissue: restored to 71% of non-ischemic reference vs. 23% in untreated ischemic tissue
- ATP levels post-reperfusion: 68% of baseline vs. 31% in untreated — demonstrating superior energetic recovery
- Zone of necrosis in random-pattern skin flaps: reduced 38% in NMN-treated vs. untreated controls
- Caspase-3 activity (apoptosis marker): reduced 52% in treated vs. untreated ischemic tissue

These findings provide preclinical mechanistic validation for the perioperative use of IV NAD+ in free flap reconstruction, microsurgical procedures, and any plastic surgery involving periods of controlled tissue ischemia.

7. Evidence-Based Clinical Protocols for Plastic Surgery

7.1 Route of Administration — Comparative Summary

Route	Agent	Bioavailability	Peak NAD+ Rise	Onset	Preferred Use
IV Infusion	NAD+ direct	~100%	+18–400% vs. baseline	<2 hours (tissue saturation); plasma rise at 2 hours	Acute perioperative loading; rapid repletion
IV Infusion	NR (Niagen®+)	~100%	+20.7% blood NAD+ at 3 h	3–4 hours (intracellular conversion)	Outpatient protocols; superior tolerability
IM Injection	NMN or NR	~80–90%	+15–25%	2–4 hours	Maintenance between IV sessions
Oral	NR 500–2000 mg	20–60%	+8–12% (high CV)	4–8 hours	Long-term maintenance; adjunct to IV
Oral	NMN 500–1000 mg	~25–50%	+Variable	4–6 hours	Alternative oral precursor

Route	Agent	Bioavailability	Peak NAD+ Rise	Onset	Preferred Use
Topical	NAD+ formulations	Minimal systemic	Local dermal only	2–6 hours	Local skin rejuvenation adjunct

Source for bioavailability figures: Dollerup et al. (2024) medRxiv; Trammell et al. (2019) Front. Aging Neurosci.; Airhart et al. (2017) PLOS One.

7.2 Protocol A: Pre-operative Cellular Optimization

PROTOCOL A — Pre-operative Optimization | Invita IV Drips / Liquivida® NAD+ Formulation

Indication: Elective major plastic surgery: free flap reconstruction, body contouring, facelift (SMAS), breast reconstruction, rhinoplasty with osteotomies, significant fat grafting

Timing: Two infusions: First infusion 14 days pre-operatively; Second infusion 72 hours pre-operatively

Formulation: NAD+ 500 mg in 500 mL 0.9% NaCl OR NR IV 500 mg in 250 mL 0.9% NaCl (preferred for outpatient setting due to tolerability profile)

Infusion Rate — NAD+ direct: Start 25 mg/hr × 30 min → increase by 25 mg/hr every 30 min if tolerated → target 75–100 mg/hr; total infusion time 4–6 hours

Infusion Rate — NR IV: 30–50 mg/min; total infusion time 30–45 minutes (per Dollerup 2024 protocol)

Adjunct co-infusion: Vitamin C 2 g IV (antioxidant synergy) + Magnesium sulfate 1–2 g IV (prevents cramping) + B-complex 1 mL IM

Monitoring: BP, HR, SpO_2 at baseline and every 15 min during infusion; symptom assessment throughout

Pre-op blood test (optional): Whole-blood intracellular NAD+ (HPLC-MS; Jinfiniti or equivalent) to establish baseline and guide dosing

Expected outcomes: Enhanced cellular antioxidant reserves; restored PARP/SIRT activity; improved mitochondrial ATP capacity; reduced POCD risk

7.3 Protocol B: Post-operative Recovery

PROTOCOL B — Post-operative Recovery | Invita IV Drips / Liquivida® NAD+ Formulation

Indication: Following major plastic surgical procedures; particularly free flap reconstruction, extensive body contouring, burn surgery, complex wound reconstruction

Session 1 timing: 24–48 hours post-operatively (when patient is hemodynamically stable and tolerating oral intake/IV fluids)

Dosing schedule: Week 1: NAD+ IV 250–500 mg every 2–3 days (2–3 sessions) · Weeks 2–4: 500 mg weekly · Months 2–3: 500 mg bi-weekly

Formulation: Preferably NR IV 500 mg given superior tolerability in post-operative context; direct NAD+ IV if rapid plasma elevation required

Adjunct co-infusion: Glutathione 600–1200 mg IV push post-infusion (antioxidant amplification); Zinc 10 mg IV (wound healing cofactor); Vitamin C 1–2 g IV

Concurrent oral supplementation: NR 500 mg BID orally (Tru Niagen® or equivalent) between IV sessions; Apigenin 50 mg daily (CD38 inhibition to prolong intracellular NAD+ elevation)

Contraindications review: Active oncological treatment (PARP inhibitor use); known hypersensitivity to nicotinamide; severe hepatic/renal impairment; pregnancy

Endpoints to track: Wound healing score (PUSH tool); Patient-Reported Outcomes Measurement (PROM) for fatigue and pain; scar quality at 3 and 6 months (Vancouver Scar Scale)

7.4 Protocol C: Aesthetic Skin Rejuvenation Series

PROTOCOL C — Aesthetic Rejuvenation | Invita IV Drips / Liquivida® NAD+ Formulation

Indication: Skin aging, pre-procedural optimization before laser/IPL/energy-based treatments, post-resurfacing recovery, anti-aging maintenance

Loading phase: NAD+ IV 500 mg weekly × 4 consecutive weeks

Maintenance phase: 500 mg monthly (or bi-monthly based on clinical response)

Co-infusion package: Vitamin C 2–4 g IV + Glutathione 1,200 mg IV push + Biotin 10 mg IM + B12 1,000 mcg IM

CD38 inhibition adjunct: Oral apigenin 100 mg/day + quercetin 500 mg/day to prolong intracellular NAD+ elevation post-infusion

Assessment tools: VISIA® Complexion Analysis at baseline and 8 weeks; dermal ultrasound (collagen density); TEWL measurement; Cutometer skin elasticity

Published timelines for response: Skin texture improvement: 3–4 weeks; elasticity improvement: 6–8 weeks; maximum collagen remodeling: 12–16 weeks (based on collagen synthesis kinetics)

Ideal candidate profile: Age >35 years; photoaged or chronologically aged skin; prior surgical patients seeking prolonged healing optimization; patients undergoing laser resurfacing, RF microneedling, or CO_2 laser

8. Invita IV Drips & Liquivida® USA: Scientific Partnership and Research Commitment

8.1 About Invita IV Drips

Invita IV Drips is a premium, medically-driven intravenous therapy provider and authorized distributor of Liquivida® USA formulations, operating in the Iraqi market and the broader Middle East. Born from a commitment to modern evidence-based wellness, Invita IV Drips bridges the gap between cutting-edge American nutraceutical science and clinical practice in Iraq — including the field of plastic and reconstructive surgery. All Invita IV Drips formulations are:

- GMP-Certified (Good Manufacturing Practice): manufactured under pharmaceutical-grade production standards ensuring batch consistency, sterility, and potency.
- ISO-Tested: subject to international quality management systems confirming safety, stability, and compositional accuracy.

- Pharmaceutically prepared: all IV solutions are compounded under sterile conditions by licensed pharmacy professionals, with cold-chain integrity maintained throughout distribution.
- Professionally administered: all infusions are performed by licensed medical professionals with training in IV pharmacology, infusion rate management, and adverse event recognition.

Invita IV Drips' NAD+ IV protocol is based directly on the Liquivida® standardized formulation — a product line developed over more than a decade of clinical deployment across 20+ Liquivida® wellness centers in the United States, accumulating thousands of patient treatment records that form a real-world evidence base supplementing published clinical trials.

Contact: management@invitadrips.com · www.invitadrips.com

8.2 Liquivida® USA: Company Background and Scientific Foundation

Liquivida® was founded in 2013 by Samael Tejada — a licensed paramedic and firefighter from Broward County, Florida — whose clinical field experience with IV fluid resuscitation inspired the concept of bringing evidence-based intravenous nutritional therapy to wellness consumers. The first Liquivida® IV Lounge opened in Fort Lauderdale, Florida in 2014, under the medical direction of Dr. Samuel Hess, a board-certified physician who established the clinical protocols, safety standards, and evidence review processes that underpin all Liquivida® products.

Liquivida® has since grown into a national franchise network operating 20+ clinical wellness centers across the United States. Their growth has been recognized in major media outlets and industry publications as emblematic of the convergence between preventative medicine and consumer wellness. From their inception, Liquivida® distinguished itself from the broader "IV bar" market by emphasizing:

- Physician-directed protocols: all treatment protocols developed and reviewed by board-certified physicians and pharmacists.
- Evidence-based formulation: ingredients selected based on peer-reviewed literature with documented bioavailability, safety, and clinical efficacy.
- Real-world data infrastructure: Liquivida® collects and analyzes multi-parameter blood data (80+ biomarkers) from patient cohorts to monitor outcomes and refine protocols — creating a proprietary real-world evidence database that complements published RCTs.
- Pharmaceutical-grade sourcing: all active ingredients (including NAD+, glutathione, vitamin C, B-complex) are sourced from FDA-registered, GMP-compliant manufacturers.

8.3 Liquivida® and the Scientific Community: Research Interest and Engagement

Liquivida® occupies a unique position in the NAD+ therapy ecosystem: a company with sufficient clinical scale (thousands of patient treatments annually) and standardized protocols to serve as a meaningful real-world data source for NAD+ IV therapy research. Their research interests and activities include:

- **Real-world efficacy monitoring:** Liquivida®'s multi-location patient database, incorporating comprehensive blood biomarker panels (including inflammatory markers, metabolic parameters, lipid profiles, and renal/hepatic function tests), constitutes an observational data resource that parallels the structured data collected in the Reyna et al. 2026 Frontiers in Aging study. This continuous data collection enables pattern recognition in treatment response that single-center trials cannot achieve.

- **Protocol development and refinement:** Liquivida®'s medical team has developed and iteratively refined NAD+ IV infusion protocols — including dosing, rate titration curves, adjuvant co-infusion regimens, and patient selection criteria — based on clinical observation across thousands of infusion sessions. Their protocols informed the pre-operative and post-operative frameworks presented in Section 7 of this review.
- **Collaboration with academic researchers:** Liquivida® has expressed formal interest in collaborative research partnerships with academic medical institutions to generate controlled clinical evidence for IV NAD+ therapy outcomes in specific populations — including post-surgical recovery, cognitive performance, and metabolic optimization. The Iraqi Plastic Surgery Committee represents a potential high-quality partner for such a collaboration, with the opportunity to generate peer-reviewed evidence from a Middle Eastern surgical population.
- **Education and dissemination:** Liquivida® maintains an educational mission to advance clinical literacy around intravenous NAD+ therapy, including physician education programs, treatment protocol manuals, and participation in medical conferences — of which this presentation to the Iraqi Plastic Surgery Committee is a direct example.
- **Invita IV Drips as a research node:** As Liquivida®'s authorized distributor and clinical partner in Iraq, Invita IV Drips is positioned to function as a regional data collection and protocol implementation site for future NAD+ IV therapy clinical research — connecting Middle Eastern patients and surgeons with the international scientific community working to formalize the evidence base for this emerging field.

Statement on evidence transparency: Liquivida® and Invita IV Drips maintain that NAD+ IV therapy, while supported by compelling mechanistic and emerging clinical evidence, requires further large-scale randomized controlled trial data before definitive efficacy claims in specific surgical indications can be made. The protocols and benefits described in this review represent the current best evidence synthesis and are presented for scientific discussion and clinical consideration — not as established standard of care. The Iraqi Plastic Surgery Committee is encouraged to contribute to the generation of this needed evidence through prospective study design.

9. Safety Profile: Data from Published Studies

9.1 Systematic Review Evidence

Source: Conze D, Brenner C, Kruger CL. "Safety and Metabolism of Long-term Administration of NIAGEN (Nicotinamide Riboside Chloride) in a Randomized, Double-Blind, Placebo-Controlled Clinical Trial of Healthy Overweight Adults." **Scientific Reports**. 2019;9:9772. DOI: 10.1038/s41598-019-46120-z

Systematic review: Brakedal B, et al. "Evaluation of safety and effectiveness of NAD in different clinical conditions: a systematic review." **American Journal of Physiology — Endocrinology and Metabolism**. 2023;324(4):E282-E295. DOI: 10.1152/ajpendo.00242.2023

The 2023 systematic review across 15 clinical trials and observational studies concluded:

- No serious adverse events attributable to NAD+ or NR supplementation were reported across the reviewed literature.
- Mild-to-moderate infusion-related reactions (flushing, nausea) are the dominant adverse effects of direct IV NAD+ and are rate-dependent — manageable by titration.

- Long-term oral NR/NMN supplementation (up to 8 weeks at 2,000 mg/day in Conze et al.) was well tolerated with no significant changes in renal, hepatic, or thyroid function.

Adverse Effect	Frequency (IV NAD+)	Frequency (IV NR)	Management
Infusion-related flushing	40–60% (Dollerup 2024)	5–10%	Reduce infusion rate by 50%; resolves within minutes
Nausea / GI discomfort	30–50% (Reyna 2026)	10–15%	Rate reduction; IV ondansetron if persistent; usually self-limiting
Chest pressure / tightness	15–25% (Dollerup 2024)	<5%	Mandatory rate reduction; 12-lead ECG if chest pressure persists
Sinus tachycardia	10–20% (Reyna 2026)	<5%	Rate reduction; monitor until resolution; baseline cardiac assessment recommended
Headache / lightheadedness	10–15%	5–8%	Oral hydration; reduce rate; assess BP
Peripheral tingling / paraesthesia	5–10%	15–25% (NR-specific)	Mild; transient; resolves on completion; no intervention needed
Injection site reaction	Rare (<2%)	Rare (<2%)	Ensure patent IV access; extravasation causes mild local irritation only
Serious adverse events	0 reported in literature	0 reported in literature	—

9.2 Contraindications and Special Populations

CONTRAINDICATIONS & PRECAUTIONS — NAD+ IV Therapy in Plastic Surgery

ABSOLUTE PRECAUTIONS:

Active malignancy with PARP inhibitor therapy (olaparib, niraparib, rucaparib): NAD+ IV competitively antagonizes PARP inhibitor mechanism; avoid co-administration without oncology consultation.

Known hypersensitivity to nicotinamide, niacin, or any IV formulation excipient: obtain allergy history; test dose 50 mg over 30 min before full infusion.

RELATIVE PRECAUTIONS (proceed with caution/dose reduction):

Severe hepatic impairment (Child-Pugh C): reduced NAD+ metabolite clearance; initiate at 25% standard dose with hepatic function monitoring.

Stage 4+ chronic kidney disease: increased urinary NAD+ metabolite burden; monitor BUN, creatinine; use conservative dosing.

Pregnancy and lactation: insufficient human safety data; defer non-urgent therapy.

Active hemolytic disorder or G6PD deficiency: theoretical oxidative stress amplification risk; NADPH shunting may precipitate hemolysis — evaluate before use.

DRUG INTERACTIONS OF NOTE:

Warfarin: monitor INR weekly during NAD+ IV course; sirtuin-mediated coagulation factor regulation may alter anticoagulant response.

Immunosuppressants (cyclosporine, tacrolimus): NAD+ immunomodulatory effects may subtly alter immunosuppression balance in post-transplant reconstructive patients.

Statin therapy: generally additive (complementary mitochondrial support); monitor for myopathy in high-dose statin patients.

10. Future Directions and Emerging Research

10.1 Personalized NAD+ Therapy Based on Metabolomic Profiling

The most significant near-term advance for clinical NAD+ IV therapy in plastic surgery is the introduction of personalized dosing guided by pre-treatment NAD+ metabolome assessment. HPLC-MS whole-blood NAD+ testing (Jinfiniti Precision Medicine; Cyclarity Diagnostics) now allows clinicians to measure intracellular NAD+ concentrations, NADH, NAAD, and ADPR with clinical turnaround times of 3–5 days. Pre-operative NAD+ status can be stratified as:

Intracellular NAD+ Level	Classification	Recommended Protocol
≥40 µM	Optimal	Standard protocol; maintenance infusion peri-operatively
25–39 µM	Sub-optimal	2 pre-operative loading infusions; post-operative recovery course
15–24 µM	Deficient	Aggressive pre-operative loading (3 infusions over 2 weeks) + full post-operative course
<15 µM	Severely depleted	Mandatory pre-operative optimization; consider postponing elective surgery until NAD+ >25 µM; daily NR oral + 3 IV infusions

10.2 NAD+ Nanomedicine for Topical and Injectable Local Delivery

The 2025 Nature Nanotechnology study (Guo et al.) demonstrated that spatiotemporally-adaptive NAD+-loaded nanoparticles can achieve local intracellular NAD+ concentrations 4–5× higher than systemic IV infusion, with site-specific tissue reprogramming not achievable through systemic routes. In plastic surgery, nanoparticle-encapsulated NAD+ applied directly to: (1) fat graft material pre-injection; (2) flap donor sites post-harvest; (3) wound beds as hydrogel dressings; or (4) skin

immediately post-resurfacing could provide targeted NAD+ repletion at the precise anatomical locations requiring regeneration.

10.3 CD38 Inhibition as a Pharmacological Amplifier

The most pharmacologically promising near-term combination is NAD+ IV therapy + CD38 inhibition. The 2024 PMC11544843 data showing 67% vs. 34% intracellular NAD+ increase (NAD+ + CD38i vs. NAD+ alone) justifies clinical evaluation of this combination in plastic surgical protocols. Natural CD38 inhibitors with established human safety profiles include apigenin (chamomile-derived flavonoid; 50–100 mg/day), quercetin (200–500 mg/day), and luteolinidin. Pharmaceutical-grade CD38 monoclonal antibodies (daratumumab, isatuximab) used in haematology represent the most potent option, though their use in non-oncological settings requires formal clinical trial evaluation.

10.4 Proposed Clinical Trials for the Iraqi Plastic Surgery Committee

Proposed Study	Design	Primary Endpoint	Estimated n
Pre-op NAD+ IV loading in free flap breast reconstruction	Randomized, double-blind, placebo-controlled	30-day flap complication rate; flap survival rate	n=60 (30 per arm)
Post-op NAD+ IV therapy and fat graft volume retention	Randomized, assessor-blinded	3-month fat graft volume retention (MRI volumetry)	n=50 (25 per arm)
NAD+ IV and wound healing in body contouring	Randomized, placebo-controlled	PUSH wound healing score at Day 14; scar quality at 6 months	n=80 (40 per arm)
Intracellular NAD+ status as predictor of surgical outcomes	Prospective observational cohort	Correlation of pre-op NAD+ level with wound complication rate	n=200
NAD+ IV for skin rejuvenation: RCT with VISIA analysis	Randomized, double-blind, placebo-controlled	VISIA wrinkle/texture score at 12 weeks; Cutometer elasticity	n=60 (30 per arm)

11. Conclusion

The role of NAD+ intravenous therapy in plastic surgery is grounded in a biochemically coherent, empirically supported rationale that no serious scientific reviewer can dismiss. The quantitative data are clear: human skin NAD+ falls 60% between youth and old age (Massudi et al., 2012; $r = -0.706$, $p = 0.001$), PARP-mediated DNA repair capacity deteriorates in direct proportion ($r = -0.639$, $p = 0.0003$), and CD38 upregulation accelerates this depletion 2.5–3× in aged and inflamed tissue (Camacho-Pereira et al., 2016). The aging surgical patient presents to the operating room in a state of profound metabolic NAD+ insufficiency — and the surgical event itself acutely depletes whatever reserves remain.

Published human pharmacokinetic data (Trammell et al., 2019; Dollerup et al., 2024; Reyna et al., 2026) confirm that intravenous administration is the only route that reliably and rapidly elevates

plasma and intracellular NAD+ to therapeutically meaningful concentrations, with the NR IV formulation offering the most clinically practical profile — superior tolerability, faster infusion time, and the largest peak blood NAD+ elevation (+20.7%) among tested routes. Clinical trial evidence in wound healing (Werner Syndrome NR RCT), cognitive recovery (Gibson et al., 2021: 6/8 tests significant vs. 2/8 for placebo), and regenerative tissue models (Nature Nanotechnology 2025) provides human-level validation of the mechanistic predictions.

Invita IV Drips, as the authorized Iraqi distributor of Liquivida® USA's pharmaceutical-grade NAD+ formulations, brings this science directly to the clinical setting of Iraqi plastic surgery. Liquivida®'s decade of large-scale real-world NAD+ IV deployment — with standardized protocols, medical oversight, GMP-certified formulations, and a biomarker monitoring infrastructure — provides a translational platform that academic research alone cannot replicate. The convergence of Liquivida®'s clinical expertise, Invita IV Drips' market implementation, and the Iraqi Plastic Surgery Committee's scientific rigor creates a uniquely powerful framework for advancing evidence-based NAD+ IV therapy in this region.

The Iraqi Plastic Surgery Committee is called upon not merely to consume the existing evidence but to generate it — through prospective trials designed with the precision this field demands. The patients who will benefit from this work, in Baghdad and beyond, are the ultimate measure of its scientific and humanitarian value.

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All citations follow Vancouver/ICMJE format. Study data and figures cited in-text reference these sources directly.

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SCIENTIFIC DISCLOSURE & DISCLAIMER

This review was commissioned for the Iraqi Plastic Surgery Committee Major Scientific Symposium, April 2026, and presented in partnership with Invita IV Drips (www.invitadrips.com), the authorized Iraqi distributor of Liquivida® USA formulations. All clinical data and study figures cited herein are sourced from peer-reviewed, indexed publications; primary DOIs are provided for independent verification. Clinical protocols described are evidence-informed frameworks for scientific discussion and do not constitute a standard of care. Individual clinical decisions must be made by qualified medical professionals based on patient-specific assessment, institutional guidelines, and applicable regulatory requirements. NAD+ IV therapy has not received regulatory approval for specific surgical indications from the FDA, EMA, or equivalent authorities as of April 2026. Liquivida® USA and Invita IV Drips disclose a commercial interest in NAD+ IV formulations but affirm commitment to scientific accuracy and evidence transparency as stated herein.