

Role of Glutamine Supplementation in Wound Healing: A Prospective Comparative Study

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Abstract

Background: Wound healing is a complicated and well-coordinated process including inflammatory, proliferative, and remodeling phases and requires adequate nutrition. Glutamine acts as a key metabolic substrate for fast proliferating and immune cells, as well as it could promote collagen production, regeneration, and host protection. However, clinical efficacy of this substance in wound healing varies. The present study aims to investigate the effect of glutamine on wound-healing outcomes in comparison with standard wound care. **Material and Methods:** A prospective comparative study was conducted in a tertiary care hospital from June 2025 to June 2026 among 90 patients with wounds requiring wound management and follow-up visits. They were divided into the control group and glutamine group with 45 people in each group who were provided with standard wound care and standard wound care + oral glutamine, respectively. The following outcome measures were assessed during follow-up visits: wound area, wound-depth reduction, granulation tissue formation, epithelialization, biochemical indicators, pain score, complications, and hospital stay. Statistical analysis was done with IBM SPSS Statistics 26.0; $p < 0.05$ was considered statistically significant. **Results:** Baseline demographic, clinical, wound, and biochemical characteristics were comparable between groups. The glutamine group demonstrated greater reduction in wound area during follow-up, with significantly higher percentage wound-area reduction from Day 7 onward. Complete epithelialization at Day 28 occurred in 60.0% versus 35.6%, while complete wound healing was achieved in 84.4% versus 64.4% in the glutamine and control groups, respectively. Mean time to healing was shorter with glutamine. Good granulation tissue formation and reduction in wound depth were significantly greater in the glutamine group. Serum albumin increased and CRP decreased significantly more with glutamine. Hospital stay and pain scores were also lower. **Conclusion:** Glutamine supplementation as a component of standard wound management resulted in better wound healing, wound-area reduction, granulation tissue formation, and shorter healing time. Larger randomized trials are required to confirm the clinical utility of glutamine supplementation.

Keywords: Glutamine; Wound healing; Granulation tissue; Epithelialization; Nutritional supplementation.

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INTRODUCTION

Wound healing is a complicated and highly coordinated biological process, including haemostasis, inflammation, proliferation, and tissue remodeling.^[1] Wound healing success depends on proper cellular activity, collagen production, angiogenesis, immune reactions, and restoration of the extracellular matrix.^[2] Nutritional status plays an important role in the described processes, and its insufficiency, in particular, energy, protein, and amino acid deficiencies, could impair wound healing, increase inflammation, susceptibility to infections, and the time required for the wound to close.^[3] Consequently, nutrition optimization is a key part of wound management.^[4] Glutamine is the main free amino acid in the human body and serves as the main metabolic substrate for rapidly proliferating cells, for example, enterocytes, fibroblasts, lymphocytes, and others.^[5] In conditions of physiological stress, injuries, infection, and other kinds of tissue damage, the demand for glutamine could significantly increase.^[6] It participates in nitrogen transport, nucleotide synthesis, redox regulation, immune reactions, and protein metabolism.^[7] Regarding the process of wound healing, glutamine may

contribute to fibroblast proliferation, collagen production, immune cell function, and tissue repair.^[8]

There is some inconsistency in the results of clinical research on the use of glutamine as an adjunct for wound healing. Some studies show positive effects of this substance on wound closure, granulation tissue formation, decreased inflammation, and wound healing time, especially for patients with elevated metabolic stress.^[9] However, there is variability in patient population, wound characteristics, nutritional status, doses of glutamine supplementation, and concomitant nutritional interventions that complicates the interpretation of research. Moreover, the lack of positive effects of glutamine

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supplementation was found in large randomized trials. Therefore, the necessity of further clinical trials on glutamine in wound healing is obvious.

Consequently, it is crucial to investigate the clinical effect of glutamine supplementation on wound healing process as an adjunct to standard wound management. The current study aims to evaluate the effect of glutamine on wound healing by comparing wound-healing process, wound-area reduction, time to complete wound healing, granulation tissue formation, biochemical indicators, pain score, complications, and length of hospital stay between the control and glutamine groups receiving standard wound care and standard wound care + oral glutamine, respectively.

MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of Surgery in a tertiary care hospital from June 2025 to June 2026 among 90 patients with wounds requiring wound care and follow-up visits. They were randomized to the control group and the glutamine group in equal proportions with 45 patients in each group. The study protocol was approved by the Institutional Ethics Committee, and all participants gave written informed consent.

For inclusion in this study, patients were required to be aged ≥ 18 years old with clinically diagnosed wounds requiring wound management and adequate follow-up. Exclusion criteria were serious systemic illness, known malignancy, renal or hepatic dysfunction, sensitivity to glutamine, or any other nutritional supplement taken to affect wound healing. Baseline data of age, sex, body mass index (BMI), comorbidities, smoking, duration of the wound, wound area, wound depth, infection, slough, granulation tissue, and pain severity were collected with the help of the standardized case-record form.

All patients received standard wound care according to the institutional protocol that includes wound cleansing,

dressing, debridement if needed, infection control, nutritional advice, and managing underlying comorbidities. Patients in the glutamine group received additionally oral glutamine supplementation at the predefined therapeutic dose in accordance with the study protocol, whereas patients in the control group received standard wound care only. Wound characteristics were assessed at baseline and follow-up visits, including wound area, wound depth, granulation tissue, epithelialization, wound infection, pain score, and complications. Clinical wound healing was assessed, and the percentage reduction in wound area was calculated.

The primary outcome of this study was wound-area reduction and percentage reduction in wound area during the follow-up period. Secondary outcomes were complete epithelialization, time to complete wound healing, granulation tissue formation, changes in the level of serum albumin and C-reactive protein (CRP), pain score, complications, and length of hospital stay.

Statistical analyses were performed with IBM SPSS Statistics, version 26.0. The continuous variables were represented as mean $\pm$ standard deviation, and categorical variables – as number (%). Independent Student's t-test or non-parametric tests were used for continuous variables, and chi-square test or Fisher's exact test for categorical variables. Repeated measurements were analyzed with the use of repeated-measures analysis of variance or mixed-effects models. The p-value < 0.05 was considered as statistically significant.

RESULTS

The total of 90 participants was included in this study; 45 were in the control group and 45 – in the glutamine group. There were no significant differences in age between groups (control: 47.6 ± 11.8 years; glutamine: 46.9 ± 12.1 years). The proportion of males was 64.4% in the control group and 62.2% in the glutamine group. BMI values did not differ between groups and there were no significant differences in proportions with diabetes mellitus, hypertension, or smoking [Table 1].

Table 1: Baseline Demographic Characteristics of the Study Participants

Variable	Control Group (n=45)	Glutamine Group (n=45)	p-value
Age (years), mean $\pm$ SD	47.6 ± 11.8	46.9 ± 12.1	0.782
Male, N (%)	29 (64.4%)	28 (62.2%)	0.824
Female, N (%)	16 (35.6%)	17 (37.8%)	
BMI (kg/m ²), mean $\pm$ SD	24.8 ± 3.6	25.1 ± 3.8	0.704
Diabetes mellitus, N (%)	19 (42.2%)	20 (44.4%)	0.831
Hypertension, N (%)	17 (37.8%)	16 (35.6%)	0.824
Smoking, N (%)	14 (31.1%)	13 (28.9%)	0.813
Duration of wound (days), mean $\pm$ SD	12.4 ± 5.7	12.8 ± 5.9	0.749

Patients in the control and glutamine groups had analogous wound characteristics at baseline. There were no significant differences in wound area (control: 18.6 ± 7.4 cm²; glutamine: 19.1 ± 7.8 cm²) and wound depth between groups.

The proportion of patients with wound infection, slough, and granulation tissue was comparable, as well as prevalence of moderate-to-severe pain, which means there were no significant baseline differences [Table 2].

Table 2: Baseline Clinical Characteristics of the Wound

Variable	Control Group (n=45)	Glutamine Group (n=45)	p-value
Wound area (cm ²), mean $\pm$ SD	18.6 ± 7.4	19.1 ± 7.8	0.754
Wound depth (mm), mean $\pm$ SD	5.8 ± 2.1	5.9 ± 2.3	0.833
Wound infection, N (%)	13 (28.9%)	12 (26.7%)	0.809
Slough present, N (%)	21 (46.7%)	22 (48.9%)	0.831
Granulation tissue present, N (%)	18 (40.0%)	17 (37.8%)	0.826
Moderate/severe pain, N (%)	25 (55.6%)	24 (53.3%)	0.829

There were no statistically significant differences in biochemical and nutritional indicators at baseline between the control and glutamine groups. There were no differences

in mean hemoglobin, serum albumin, total protein, total leukocyte count, CRP, and serum glucose between groups [Table 3].

Table 3: Baseline Biochemical and Nutritional Parameters

Parameter	Control Group (n=45)	Glutamine Group (n=45)	p-value
Hemoglobin (g/dL), mean $\pm$ SD	11.2 $\pm$ 1.4	11.4 $\pm$ 1.5	0.516
Serum albumin (g/dL), mean $\pm$ SD	3.21 $\pm$ 0.42	3.24 $\pm$ 0.39	0.721
Total protein (g/dL), mean $\pm$ SD	6.42 $\pm$ 0.61	6.48 $\pm$ 0.58	0.631
Total leukocyte count (/mm ³), mean $\pm$ SD	8420 $\pm$ 2110	8280 $\pm$ 2060	0.754
CRP (mg/L), mean $\pm$ SD	18.4 $\pm$ 9.6	18.1 $\pm$ 9.3	0.882
Serum glucose (mg/dL), mean $\pm$ SD	132.6 $\pm$ 28.4	135.1 $\pm$ 30.1	0.685

Wound area reduced in both cohorts during follow-up period; however, the reduction was greater in the glutamine group. Intergroup difference was not statistically significant during

the early follow-up period; however, at Day 21 the mean wound area became significantly smaller in the glutamine group, and it became more prominent at Day 28 [Table 4].

Table 4: Change in Wound Area During Follow-up

Follow-up	Control Group (n=45)	Glutamine Group (n=45)	p-value
Baseline	18.6 $\pm$ 7.4	19.1 $\pm$ 7.8	0.754
Day 7	15.8 $\pm$ 6.8	15.1 $\pm$ 6.7	0.624
Day 14	12.9 $\pm$ 6.1	10.8 $\pm$ 5.4	0.089
Day 21	10.2 $\pm$ 5.7	7.2 $\pm$ 4.6	0.009
Day 28	8.1 $\pm$ 5.2	4.9 $\pm$ 3.8	0.002

Percentage wound area reduction increased in both groups during the follow-up period. Intergroup difference started to appear from Day 7 and became statistically significant and

greater during subsequent visits. At Day 28, the mean percentage reduction was significantly higher among patients receiving glutamine supplementation [Table 5].

Table 5: Percentage Reduction in Wound Area During Follow-up

Follow-up	Control Group (n=45)	Glutamine Group (n=45)	p-value
Day 7	15.1 $\pm$ 8.4%	20.8 $\pm$ 9.1%	0.004
Day 14	30.7 $\pm$ 12.6%	43.8 $\pm$ 14.2%	<0.001
Day 21	45.2 $\pm$ 15.8%	61.9 $\pm$ 16.4%	<0.001
Day 28	56.4 $\pm$ 18.1%	74.6 $\pm$ 15.9%	<0.001

Complete epithelialization was detected in 35.6% of patients in the control group and 60.0% in the glutamine group at Day 28. Good granulation tissue, reduction in wound depth by at least 50%, and the absence of slough was more common in the glutamine group. The intergroup difference was

statistically significant concerning complete epithelialization, granulation, wound depth reduction, and the absence of slough; however, the absence of wound infection was similar between groups [Table 6].

Table 6: Wound Healing Parameters at Day 28

Parameter	Control Group (n=45)	Glutamine Group (n=45)	p-value
Complete epithelialization, N (%)	16 (35.6%)	27 (60.0%)	0.024
Good granulation tissue, N (%)	25 (55.6%)	35 (77.8%)	0.029
Reduction in wound depth $\geq$ 50%, N (%)	23 (51.1%)	33 (73.3%)	0.034
Slough absent, N (%)	28 (62.2%)	38 (84.4%)	0.018
Wound infection absent, N (%)	35 (77.8%)	40 (88.9%)	0.148

Complete wound healing was achieved in 64.4% of patients in the control group and 84.4% in the glutamine group. Thus, significantly higher proportion of patients was healed among

those receiving glutamine supplementation. In addition, the mean time to wound healing was shorter in the glutamine group [Table 7].

Table 7: Time to Complete Wound Healing

Outcome	Control Group (n=45)	Glutamine Group (n=45)	p-value
Patients achieving complete healing, N (%)	29 (64.4%)	38 (84.4%)	0.030
Time to complete healing (days), mean $\pm$ SD	35.8 $\pm$ 10.6	28.4 $\pm$ 8.7	<0.001

The distribution of granulation tissue status was analogous at baseline in both groups, and the most patients had poor or moderate granulation. By Day 28, there was a considerable

increase in the proportion of patients with good granulation tissue in both groups, and it was significantly greater in the glutamine group. Poor granulation tissue was less prevalent

among patients receiving glutamine supplementation [Table 8].

Table 8: Change in Granulation Tissue During Follow-up

Granulation status	Control Group (n=45)	Glutamine Group (n=45)	p-value
Baseline			
Poor, N (%)	27 (60.0%)	28 (62.2%)	0.827
Moderate, N (%)	13 (28.9%)	12 (26.7%)	
Good, N (%)	5 (11.1%)	5 (11.1%)	
Day 28			
Poor, N (%)	8 (17.8%)	3 (6.7%)	0.041
Moderate, N (%)	12 (26.7%)	7 (15.6%)	
Good, N (%)	25 (55.6%)	35 (77.8%)	

At baseline, the serum albumin increased in both groups, and the increase was significantly higher in the glutamine group. CRP levels declined in both cohorts from baseline and were significantly lower in the glutamine group at Day 28. There

was a tendency toward hemoglobin increase during the follow-up in both groups; however, the intergroup difference at Day 28 did not reach the statistical significance [Table 9].

Table 9: Changes in Biochemical Parameters from Baseline to Day 28

Parameter	Control Group	Glutamine Group	p-value
Serum albumin at baseline (g/dL)	3.21 ± 0.42	3.24 ± 0.39	0.721
Serum albumin at Day 28 (g/dL)	3.42 ± 0.44	3.61 ± 0.41	0.035
CRP at baseline (mg/L)	18.4 ± 9.6	18.1 ± 9.3	0.882
CRP at Day 28 (mg/L)	11.6 ± 7.4	8.2 ± 5.8	0.017
Hemoglobin at baseline (g/dL)	11.2 ± 1.4	11.4 ± 1.5	0.516
Hemoglobin at Day 28 (g/dL)	11.7 ± 1.3	12.0 ± 1.4	0.294

Post-treatment wound infection was detected in 22.2% of patients in the control group and 11.1% in the glutamine group. Wound dehiscence, need for debridement, and delayed healing were less prevalent in the glutamine group;

however, this difference did not reach statistical significance. The proportion of patients without complications was higher in the glutamine group, but it did not differ statistically [Table 10].

Table 10: Post-treatment Wound Infection and Other Complications

Complication	Control Group (n=45)	Glutamine Group (n=45)	p-value
Wound infection, N (%)	10 (22.2%)	5 (11.1%)	0.148
Wound dehiscence, N (%)	5 (11.1%)	2 (4.4%)	0.235
Need for additional debridement, N (%)	9 (20.0%)	4 (8.9%)	0.137
Delayed healing, N (%)	12 (26.7%)	5 (11.1%)	0.057
No complication, N (%)	29 (64.4%)	37 (82.2%)	0.055

The mean length of hospital stay was significantly lower in the glutamine group compared to the control one. There were no significant differences in baseline visual analogue scale

(VAS) pain score between groups, but pain score at Days 7, 14, and 28 was significantly lower in the glutamine group [Table 11].

Table 11: Hospital Stay and Pain Score

Outcome	Control Group (n=45)	Glutamine Group (n=45)	p-value
Hospital stay (days), mean ± SD	12.8 ± 4.6	10.1 ± 3.7	0.003
Baseline pain score (VAS), mean ± SD	6.2 ± 1.4	6.1 ± 1.5	0.748
Day 7 pain score, mean ± SD	4.3 ± 1.3	3.7 ± 1.2	0.029
Day 14 pain score, mean ± SD	3.1 ± 1.1	2.4 ± 0.9	0.002
Day 28 pain score, mean ± SD	1.8 ± 0.8	1.3 ± 0.6	0.001

DISCUSSION

The results of the current study demonstrated the improvement in wound-healing process in both groups; however, patients in the glutamine group had greater wound-area reduction. The intergroup difference became obvious during the follow-up period; the glutamine group had greater percentage reduction in wound area starting from Day 7, as well as higher proportion of patients with complete epithelialization at Day 28. These findings are consistent with the previously published data indicating the possible effect of glutamine on wound healing. Zhou et al. reported on greater wound healing at Day 30 among patients receiving

enteral glutamine compared to controls (86% vs. 72%), as well as shorter length of hospital stay in their randomized controlled trial.^[10] Moreover, a systematic review and meta-analysis of 22 randomized controlled trials including 2,170 patients with burns confirmed the improvement in pooled wound-healing rates and wound-healing time with glutamine supplementation,^[11] although there was high heterogeneity across studies. Enhanced wound characteristics found in the current study were associated with the improvement of granulation tissue and greater reduction in wound depth in the glutamine group. There are several explanations for these findings. First, glutamine acts as a metabolic substrate for fast proliferating cells and takes part

in the processes of nitrogen metabolism, immune cell function, and wound healing. A systematic review of arginine and glutamine supplementation shows the improvement of several parameters, including nitrogen balance and CRP, in this population; however, there was substantial heterogeneity between the included studies.^[9] Second, in the pilot prospective trial of patients with diabetic foot ulcers, Jones et al. reported about the increase of tissue hydroxyproline after supplementation with arginine, glutamine, and β -hydroxy- β -methylbutyrate,^[12] however, it was impossible to separate the effect of each of these components.

In the current study, the reduction in CRP and increase in serum albumin were found, and these changes were more favorable in the glutamine group. These findings could be explained by the immunometabolic role of glutamine and were confirmed by the previously published studies on amino acid supplementation. Nevertheless, clinical findings are inconsistent. Heyland et al. in a large double-blind randomized trial of 1,200 patients with severe burns found that enteral glutamine did not significantly decrease the time to hospital discharge or six-month mortality compared to placebo.^[13] In addition, a systematic review and meta-analysis of six randomized trials including 1,398 patients with severe burns found that glutamine did not reduce mortality and overall infectious morbidity, but was associated with shorter hospital stay.^[14] Hence, the variations in wound type, severity of systemic illness, nutritional status, timing and dose of glutamine, and concomitant nutritional therapy may explain the heterogeneity across studies. Shorter hospitalization duration and lower pain scores in the glutamine group in the current study are another proof of potential positive effects of this supplement. Several earlier randomized trials in patients with severe burns reported about reduced hospital stay and infectious morbidity with enteral glutamine, and one randomized trial reported about fewer positive wound cultures and shorter hospitalization.^[15] However, the evidence on the effect of glutamine in diabetic foot-ulcer population is inconsistent. In a randomized controlled trial of 270 patients receiving a combination of arginine, glutamine, and β -hydroxy- β -methylbutyrate, there was no difference in wound closure or time to healing, although the benefits were found in patients with low serum albumin or impaired limb perfusion.^[16] In addition, according to the Cochrane review, there is insufficient evidence concerning the effect of nutritional interventions, including arginine/glutamine/ β -hydroxy- β -methylbutyrate supplementation in patients with diabetic foot ulcers due to limitations in study quality, indirectness, and imprecision.^[17] Thus, these findings imply that the observed benefit of glutamine in the current study should be considered in the context of patient population and treatment protocol.

CONCLUSION

Glutamine supplementation as a component of standard wound care was associated with better wound healing, wound-area reduction, formation of granulation tissue, and shorter healing time, along with favorable changes in

biochemical and clinical parameters. For proving its independent clinical efficacy and for determining patients who can benefit from its use, more properly designed studies with adequate sample size using standard glutamine dosing and specific wound type definition will be required.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Campbell A, Bae J, Hein M, Hillis SL, Rebeck ON, Rakel BA, Grice E, Gardner SE. The heterogeneous wound microbiome varies with wound care pain, dressing type, and inflammatory gene expression. *Wound Repair Regen.* 2024 Nov-Dec;32(6):811-825. doi: 10.1111/wrr.13184. Epub 2024 Apr 26. PMID: 38666460; PMCID: PMC11511792.
- Wilkinson HN, Hardman MJ. Wound healing: cellular mechanisms and pathological outcomes. *Open Biol.* 2020 Sep;10(9):200223. doi: 10.1098/rsob.200223. Epub 2020 Sep 30. PMID: 32993416; PMCID: PMC7536089.
- Seth I, Lim B, Cevik J, Gracias D, Chua M, Kenney PS, Rozen WM, Cuomo R. Impact of nutrition on skin wound healing and aesthetic outcomes: A comprehensive narrative review. *JPRAS Open.* 2024 Jan 23;39:291-302. doi: 10.1016/j.jpra.2024.01.006. PMID: 38370002; PMCID: PMC10874171.
- Daher GS, Choi KY, Wells JW, Goyal N. A Systematic Review of Oral Nutritional Supplement and Wound Healing. *Ann Otol Rhinol Laryngol.* 2022 Dec;131(12):1358-1368. doi: 10.1177/00034894211069437. Epub 2022 Jan 19. PMID: 35043693.
- Cruzat V, Macedo Rogero M, Noel Keane K, Curi R, Newsholme P. Glutamine: Metabolism and Immune Function, Supplementation and Clinical Translation. *Nutrients.* 2018 Oct 23;10(11):1564. doi: 10.3390/nu10111564. PMID: 30360490; PMCID: PMC6266414.
- Al Balushi RM, Cohen J, Banks M, Paratz JD. The clinical role of glutamine supplementation in patients with multiple trauma: a narrative review. *Anaesth Intensive Care.* 2013 Jan;41(1):24-34. doi: 10.1177/0310057X1304100106. PMID: 23362887.
- Kumar MA, Baba SK, Khan IR, Khan MS, Husain FM, Ahmad S, Haris M, Singh M, Akil ASA, Macha MA, Bhat AA. Glutamine Metabolism: Molecular Regulation, Biological Functions, and Diseases. *MedComm (2020).* 2025 Jun 25;6(7):e70120. doi: 10.1002/mco.2.70120. PMID: 40567251; PMCID: PMC12188105.
- Kesici U, Kesici S, Ulusoy H, Yucesan F, Turkmen AU, Besir A, Tuna V. Effects of glutamine on wound healing. *Int Wound J.* 2015 Jun;12(3):280-4. doi: 10.1111/iwj.12098. Epub 2013 Jun 6. PMID: 23738714; PMCID: PMC7950571.
- Arribas-López E, Zand N, Ojo O, Snowden MJ, Kochhar T. The Effect of Amino Acids on Wound Healing: A Systematic Review and Meta-Analysis on Arginine and Glutamine. *Nutrients.* 2021 Jul 22;13(8):2498. doi: 10.3390/nu13082498. PMID: 34444657; PMCID: PMC8399682.
- Zhou YP, Jiang ZM, Sun YH, Wang XR, Ma EL, Wilmore D. The effect of supplemental enteral glutamine on plasma levels, gut function, and outcome in severe burns: a randomized, double-blind, controlled clinical trial. *JPEN J Parenter Enteral Nutr.* 2003 Jul-Aug;27(4):241-5. doi: 10.1177/0148607103027004241. PMID: 12903886.
- Tao W, Xu G, Zhou J, Luo Y, Li PS. Glutamine Supplementation on Burn Patients: A Systematic Review and Meta-analysis. *J Burn*

- Care Res. 2024 May 6;45(3):675-684. doi: 10.1093/jbcr/irae007. PMID: 38243579.
12. Jones MS, Rivera M, Puccinelli CL, Wang MY, Williams SJ, Barber AE. Targeted amino acid supplementation in diabetic foot wounds: pilot data and a review of the literature. *Surg Infect (Larchmt)*. 2014 Dec;15(6):708-12. doi: 10.1089/sur.2013.158. PMID: 25215468; PMCID: PMC4268587.
 13. Heyland DK, Wibbenmeyer L, Pollack J, Friedman B, Turgeon AF, Eshraghi N, Jeschke MG, Bélisle S, Grau D, Mandell S, Velamuri SR, Hundeshagen G, Moiemmen N, Shokrollahi K, Foster K, Huss F, Collins D, Savetamal A, Gurney JM, Depetris N, Stoppe C, Ortiz-Reyes L, Garrel D, Day AG; RE-ENERGIZE Trial Team. A Randomized Trial of Enteral Glutamine for Treatment of Burn Injuries. *N Engl J Med*. 2022 Sep 15;387(11):1001-1010. doi: 10.1056/NEJMoa2203364. Epub 2022 Sep 9. PMID: 36082909.
 14. Yue HY, Wang Y, Zeng J, Jiang H, Li W. Enteral glutamine supplements for patients with severe burns: A systematic review and meta-analysis. *Chin J Traumatol*. 2024 Dec;27(6):359-367. doi: 10.1016/j.cjtee.2023.06.005. Epub 2023 Jun 28. PMID: 37460347; PMCID: PMC11624305.
 15. Pattanshetti VM, Powar RS, Godhi AS, Metgud SC. Enteral glutamine supplementation reducing infectious morbidity in burns patients: a randomised controlled trial. *Indian J Surg*. 2009 Aug;71(4):193-7. doi: 10.1007/s12262-009-0056-x. Epub 2009 Sep 2. PMID: 23133153; PMCID: PMC3452623.
 16. Armstrong DG, Hanft JR, Driver VR, Smith AP, Lazaro-Martinez JL, Reyzelman AM, Furst GJ, Vayser DJ, Cervantes HL, Snyder RJ, Moore MF, May PE, Nelson JL, Baggs GE, Voss AC; Diabetic Foot Nutrition Study Group. Effect of oral nutritional supplementation on wound healing in diabetic foot ulcers: a prospective randomized controlled trial. *Diabet Med*. 2014 Sep;31(9):1069-77. doi: 10.1111/dme.12509. Epub 2014 Jun 19. PMID: 24867069; PMCID: PMC4232867.
 17. Moore ZE, Corcoran MA, Patton D. Nutritional interventions for treating foot ulcers in people with diabetes. *Cochrane Database Syst Rev*. 2020 Jul 17;7(7):CD011378. doi: 10.1002/14651858.CD011378.pub2. PMID: 32677037; PMCID: PMC7388930.