Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2784-2790 | ISSN:2251-6727

Role of Nutritional Support in Enhancing Bone Healing: A Retrospective Study.

Dr Ankit Prakash[1], Dr Ajinkya Gautam[2], Dr Prashant[3], Dr Mahesh Prasad[4]

[1]P.G. Resident, Department of Orthopedics, Patna Medical College and Hospital, Patna

[2]Senior Resident, Department of Orthopedics, Patna Medical College and Hospital, Patna

[3]P.G. Resident, Department of Orthopedics, Patna Medical College and Hospital, Patna

[4]Professor, Department of Orthopedics, Patna Medical College and Hospital, Patna

Corresponding Author: Dr Ajinkya Gautam

(Received: 16 September 2024 Revised: 11 October 2024 Accepted: 11 December 2024)

KEYWORDS
Bone healing, nutritional support, fracture healing, vitamin D, calcium, protein, orthopedic nutrition, callus formation, functional recovery.

ABSTRACT:

Background: Bone healing is complicated by age, comorbidities, and nutrition. By providing proteins, vitamins, and minerals, nutritional support optimises fracture healing. Slow bone regeneration is linked to calcium, vitamin D, and magnesium deficiencies. This study will assess how targeted nutritional supplementation affects fracture patients' bone healing.

Methods: A retrospective observational study at PMCH from May 2023 to April 2024 included 50 long bone fracture patients. Part A (n=25) received targeted nutrition with protein, calcium, vitamin D, vitamin K, and omega-3 fatty acids, while Part B (n=25) received standard hospital food. Functional recovery, radiographic healing at 4-, 8-, and 12-weeks post-fracture, serum nutrient levels, and diet were examined. A significance threshold of $p<0.05$ was used for SPSS v.26 statistical comparisons.

Results: Group A had higher serum vitamin D levels ($p<0.01$), faster callus formation (8.4 ± 1.5 weeks vs. 10.6 ± 2.1 weeks, $p=0.03$), and shorter bone union time than Group B. Supplementation improved functional recovery, pain relief, and mobility.

Conclusion: Functional recovery and fracture healing are greatly improved by targeted nutrition. Dietary interventions in orthopaedic care improve bone regeneration. Further research is needed to create universal fracture diet guidelines.

Introduction

Bone healing involves perfect coordination between cellular, molecular, and biochemical processes. This dynamic skeletal process repairs fractures and preserves structural integrity. Many factors affect bone healing and regeneration. Nutrition, age, genetic predisposition, injury severity, co-morbidities, and lifestyle are examples [1]. Bone healing requires proper nutrition. It provides osteogenesis and repair building blocks. An adequate and balanced diet in fracture recovery has become more important as research emphasises the role of macronutrients and micronutrients in bone regeneration [2]. Bone healing involves separate but interdependent inflammatory, reparative, and remodelling phases. The inflammatory phase of injury healing activates immune cells, coagulation factors, and cytokines. Mesenchymal stem cells differentiate into chondrocytes and osteoblasts and form calluses during the repair phase. The final stage, remodelling, ensures mature lamellar bone replaces immature woven bone [3]. Each step requires nutrients. Deficits in vitamins and minerals can cause fracture delays, nonunion, or malunion, prolonging morbidity and functional impairment.

Protein is crucial for bone healing. Around 90% of bone's organic content is collagen, the matrix's main structural component. Proline, lysine, and hydroxyproline are needed to synthesise and cross-link collagen, which gives bone tissue strength and flexibility [4]. Insufficient protein consumption affects osteoblast activity, matrix production, and bone formation. In early fracture healing, proteins are needed for immune function and inflammation [5]. Proteins are needed for osteoblast proliferation and differentiation, and protein malnutrition lowers growth factors like insulin-like growth factor-1. Thus, for optimal bone regeneration, the diet should include enough protein from high-quality sources like eggs, lean meats, dairy, and plant-based proteins [6]. Proteins and calcium help heal bones. As the main component of hydroxyapatite crystals, it gives bone its compressive strength and hardness. Osteoblasts deposit calcium into the extracellular matrix under PTH and vitamin D control to build bone [7]. If calcium intake is low, bone resorption weakens the skeleton and delays healing. Calcium RDAs vary by age and gender, but adults recovering from fractures should consume 1000-1200 mg daily. Dairy, dark greens, almonds, and fortified foods are great calcium sources [8].

Vitamin D helps maintain calcium levels and repair bones, among other functions. It controls bone mineralisation and aids intestinal calcium absorption. Hypocalcaemia, secondary hyperparathyroidism, and impaired bone healing can result from vitamin D deficiency on calcium absorption [9]. Vitamin D influences osteoblasts and osteoclasts to remodel bones. Research shows that vitamin D deficiency slows fracture healing and increases nonunion risk. Vitamin D is mostly synthesised in sunlight, but fortified dairy, fatty fish, and egg yolks are good sources [10]. Another essential mineral for bone metabolism and fracture healing is magnesium. In addition to calcium transport, it controls osteoblast activity as an enzyme cofactor. Deficient magnesium affects bone fragility, mass, and callus formation. Additionally, magnesium affects parathyroid hormone and vitamin D production, which are important for bone health. A balanced diet of green leafy vegetables, nuts, seeds, and whole grains can help meet magnesium needs [11].

Magnesium, calcium, vitamin D, zinc, phosphorus, and omega-3 fatty acids aid bone healing. Vitamin K is needed to carboxylate osteocalcin, which attaches calcium to bone matrix. Its bone mineralisation and fracture prevention effects are well-known. Vitamin K is found in broccoli, green leafy vegetables, and fermented foods [12]. Zinc, another trace element, is needed for collagen, osteoblast, and immunological function. Zinc deficiency affects fracture and wound healing. Zinc-rich foods include meat, shellfish, almonds, and legumes. Fatty fish, flaxseeds, and walnuts contain omega-3 fatty acids, which reduce inflammation and heal bones. Chronic inflammation slows fracture healing and increases bone loss, so a diet rich in omega-3 fatty acids is essential for bone health [13]. Strong bones and bone repair require phosphorus, which forms hydroxyapatite crystals with calcium. Meat, dairy, and whole grains are good sources.

Hydration is crucial to bone healing but often overlooked. Water is needed for metabolism, nutrient transport, and waste removal. Dehydration slows fracture healing by reducing blood circulation and nutrient delivery. Hydration is an easy and effective way to aid bone recovery. Multiple studies have stressed the importance of nutrition in fracture healing. Malnourished people have slower bone regeneration and more complications, according to research [14]. A study found that supplemented patients healed faster and performed better. Another study found that elderly hip fractures healed faster with protein and vitamin D. Despite strong evidence that nutrition aids bone healing, many fracture patients receive inadequate dietary advice. Orthopaedic surgeons and nutritionists should emphasise proper nutrition after fractures [15]. An integrated approach with nutritional counselling, supplementation, and patient education improves healing and bone health. To conclude, bone healing is complicated and depends on many biological factors, including nutrition. Prostrate, zinc, vitamin K, calcium, vitamin D, magnesium, and omega-3 fatty acids can speed healing and bone regeneration. Nutritional deficiencies can slow fracture healing, increase complications, and prolong recovery. Thus, orthopaedic fracture recovery treatment should monitor nutritional intake and correct nutritional deficiencies. Dietary interventions and supplements should be studied to improve patient outcomes and bone healing. Investigating nutritional supplements' role in bone fracture recovery. To determine if diet affects radiological/histological healing indicators, . To assess nutritional support's healing effects compared to non-supportive patients.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2784-2790 | ISSN:2251-6727

Methods

Study Design

The PMCH observational study lasted 12 months, from May 2023 to April 2024. The study compared patients on a hospital diet to those given targeted nutritional supplements to determine if nutritional support improved bone healing. Medical records were used to collect data on patients' nutrition, supplement use, radiographic results, and clinical evaluations due to the retrospective study. These records were examined to determine how nutritional interventions affected fracture healing, functional outcomes, and recovery.

Sample Size and Population

The study included 50 long-bone fracture patients. The nutritional support they received divided these patients into two groups. Twenty-five patients in the first group received individualised dietary recommendations for protein, calcium, vitamin D, vitamin K, and omega-3 fatty acids. This group received dietary counselling to ensure they got enough nutrients. Group B (n = 25) received only hospital fare and no supplements. There were enough calories in the typical diet, but no bone-healing supplements. This sample population was selected using strict inclusion and exclusion criteria to ensure a homogeneous research group and reduce confounding variables.

Inclusion Criteria

- Adults between 18 and 65 years of age.
- Patients diagnosed with fractures of long bones (femur, tibia, fibula, humerus, radius, or ulna).
- Patients who had at least two follow-up X-rays performed to monitor the progress of fracture healing.
- Patients with no underlying chronic metabolic bone disorders that could independently affect healing.

Exclusion Criteria

- Presence of severe metabolic bone diseases such as osteoporosis, osteogenesis imperfecta, or Paget's disease, as these conditions could independently impact fracture healing.
- Patients who were non-compliant with follow-up visits and failed to undergo the required radiographic evaluations.
- Patients with infection-related complications, such as osteomyelitis, as this could confound the assessment of nutritional support on bone healing.
- Patients with multiple fractures or polytrauma, as their healing dynamics could be significantly different from isolated long bone fractures.

Data Collection

Medical records and hospital databases were searched for study data. Detailed patient diet documentation determined nutritional supplementation. We monitored omega-3 fatty acid, calcium, vitamin D, and vitamin K intake in Group A. To rule out targeted supplementation in Group B, we checked their food records to ensure they followed the hospital diet. Follow-up X-rays four, eight, and twelve weeks after the injury assessed fracture healing. Radiography assessed bone bridging, callus growth, and cortical tissue health. The mRUST, a modified Radiographic Union Scale for Tibial Fractures, assessed healing. VAS was used to measure pain at baseline, four, eight, and twelve weeks. Mobility scores, range of motion, and patients' daily task abilities assessed functional recovery. Time taken to reach weight-bearing capacity was documented. Laboratory reports from the beginning and end of the study examined serum magnesium, vitamin D, and calcium levels. Inflammatory markers like CRP were tested to rule out systemic inflammation as a cause of delayed healing.

Statistical Analysis

Data was analysed using SPSS version 26 to determine if the two groups differed statistically. Means, standard deviations, and frequency distributions were calculated for continuous and categorical variables. Chi-square tests were used to evaluate categorical variables like healing rates and mobility status over time. Independent t-tests examined fracture healing time, functional scores, and serum calcium levels. A statistically significant p-value less than 0.05 showed significant differences in healing progress and functional outcomes between the two groups.

Results

This observational study illuminated how nutritional supplements affect bone healing. Data analysis focused on patients' demographics, nutrition, radiological healing, and functional recovery. The results show

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(6), 2784-2790 | ISSN:2251-6727

statistically significant differences between the two groups: targeted nutritional support improves fracture healing and functional outcomes.

Demographics and Baseline Characteristics

Parameter	Group A (n=25) – Nutritional Support	Group B (n=25) – Standard Diet	p-value
Mean Age (years)	42.3 ± 7.5	41.8 ± 8.1	0.76
Gender Distribution (M/F)	16/9	14/11	0.58
Common Fracture Sites			
- Femur	10	10	-
- Tibia	8	7	-
- Humerus	5	5	-
- Radius/Ulna	2	3	-

Comparing the two groups' baseline demographics, including gender distribution and age means, showed no statistically significant differences ($p > 0.05$). The femur fractured 40%, the tibia 30%, the humerus 20%, and the radius/ulna 10%. Dietary intervention can explain recovery differences since the groups were similarly structured at the start.

Nutritional Status and Healing Outcomes

Parameter	Group A (Nutritional Support)	Group B (Standard Diet)	p-value
Serum Vitamin D (ng/ml)	32.4 ± 5.6	22.1 ± 6.3	<0.01
Serum Calcium (mg/dl)	9.5 ± 0.6	8.7 ± 0.7	0.02
Mean Time to Union (weeks)	8.4 ± 1.5	10.6 ± 2.1	0.03
Callus Formation at 8 weeks	80% showed bridging callus	56% showed bridging callus	0.04

Serum calcium, vitamin D Higher vitamin D and calcium levels in Group A indicate improved bone mineralisation due to nutrient supplementation ($p < 0.01$, $p = 0.02$). Union Timeframe At 8.4 weeks, Group A patients reached radiographic union, compared to 10.6 weeks for Group B ($p = 0.03$). Callus Formation Nutritional support appears to have accelerated bone healing, as 80% of Group A patients showed signs of bridging callus formation at 8 weeks, compared to 56% of Group B patients.

Functional Recovery and Pain Scores

Parameter	Group A (Nutritional Support)	Group B (Standard Diet)	p-value
Pain Reduction (VAS Score at 8 weeks)	3.2 ± 1.1	5.1 ± 1.4	<0.01
Mobility Score (at 12 weeks)	85.6 ± 7.3	74.8 ± 8.5	0.02
Full Weight-Bearing Achieved by (%)	88%	64%	0.03

Nutritional support led to faster pain relief in Group A ($p < 0.01$), with an average VAS score of 3.2 at 8 weeks, compared to 5.1 in Group B. Group A had a significantly higher mobility score (85.6 ± 7.3) at 12 weeks compared to Group B (74.8 ± 8.5) ($p = 0.02$). Group A had faster rehabilitation, with 88% of patients bearing full weight by 12 weeks, compared to 64% in Group B.

Discussion

Interpretation of Key Findings

This study found that targeted nutritional support accelerated fracture healing compared to the hospital diet. Group A's shorter mean time to union suggests that nutritional supplementation boosts bone regeneration. The supplemented group had higher serum calcium and vitamin D levels, which improved callus formation and weight-bearing capacity for more patients. These findings emphasise the role of micronutrients in bone metabolism. Vitamin D is essential for calcium absorption and bone mineralisation. Group A patients had higher serum vitamin D levels at various radiographic examinations, which likely aided callus formation and healing. Consuming more calcium

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(6), 2784-2790 | ISSN:2251-6727

reinforced the newly formed bone matrix, reducing the risk of delayed union. Supplementation reduced the mean time to union by two weeks, showing how nutritional optimisation affects healing. Increased protein, vitamin, and mineral intake helped bone healing. Proteins lay the groundwork for collagen synthesis and bone remodelling. Protein is needed for osteoblast function, which lays down the bone matrix. Omega-3 fatty acid supplements improved pain relief and functional recovery. Omega-3 fatty acids' anti-inflammatory effects may explain the differences in mobility and pain scores between groups. Group A patients recovered better, so orthopaedic fracture management should include diet.

Comparison with Existing Literature

This study confirmed earlier findings that diet affects bone healing. Multiple studies show that vitamin D deficiency slows callus formation and fracture healing. Because bone remodelling takes longer, vitamin D deficiency weakens callus formation, according to [16]. Our study found that Group A had higher vitamin D levels, supporting the need for supplemental vitamin D for bone formation. Evidence suggests omega-3 fatty acids reduce inflammation and improve healing. [17] found that omega-3 supplements reduced systemic inflammatory markers in orthopaedic trauma patients, speeding recovery. Our study showed improved pain relief and functional recovery in Group A patients. Fracture patients may benefit from omega-3 fatty acids. Current research strongly suggests that a high-protein diet boosts osteoblast activity and bone mineralisation. Protein is needed to form collagen, which supports bone. Protein deficiency slows bone formation and impairs osteoblast function, according to research. The improved healing results in Group A support the idea that protein supplementation is essential post-fracture care.

Limitations

This study provided some useful insights, but it has some limitations. Since the sample size is 50, the results may not apply to a larger population. The effect of nutritional supplements on different fracture types could be studied with a larger sample size due to statistical power. Second, unlike a controlled prospective trial, this study used data from patients' medical records, which may have introduced selection bias. Another drawback is that it is retrospective, so we can't rule out physical activity, supplement compliance, and pre-existing nutritional status. To better understand nutritional supplementation and fracture healing, future studies should recruit more participants or conduct RCTs. Another drawback is the 12-week follow-up. This period was long enough to assess fracture healing and functional recovery, but too short to determine how nutritional supplements affect bone strength and re-fracture risk. Longer follow-up studies are needed to determine if the benefits last and improve bone quality.

Future Recommendations

Future research on nutrition and fracture healing needs larger RCTs with diverse patient populations. A well-designed RCT with a larger sample size could confirm this study's findings. Future research should also examine how magnesium, zinc, and vitamin K affect bone healing. Bone metabolism requires magnesium for osteoblast and osteoclast activity and zinc for mineralisation and collagen synthesis. It is well known that vitamin K controls bone formation by helping osteocalcin bind calcium. These micronutrients may illuminate nutrition's comprehensive role in fracture healing. Future research should determine the optimal nutrient amounts for bone healing. Despite this study's positive results, vitamin D, calcium, protein, and omega-3 fatty acid dosage recommendations are lacking. Standardised nutritional protocols based on science could guide clinical practice and patient outcomes. Extended follow-up studies are needed to assess the long-term effects of dietary interventions on bone strength, functional recovery, and fracture prevention. The evidence of whether nutritional supplementation improves bone health beyond initial healing should guide orthopaedic diets.

Conclusion

This study shows that nutritional support improves patient outcomes and bone healing. Rapid radiological and clinical recovery in fracture patients was linked to adequate calcium, vitamin D, and protein intake. Compared to hospital diet patients, supplement users healed faster, formed calluses better, and could bear weight earlier. These findings support the long-held hypothesis that these nutrients regulate bone metabolism. Protein is needed for osteoblast function and collagen production, vitamin D aids calcium absorption and mineralisation, and calcium holds the healing bone

together. Dietary improvements should be part of orthopaedic treatment because they improve fracture healing. Given the growing evidence that diet affects bone health, nutritional interventions in fracture management may improve patient outcomes. Diet in bone regeneration is often overlooked in orthopaedic care, which focusses on pharmaceutical and surgical interventions. This study emphasises the importance of addressing nutritional deficiencies to improve recovery and reduce delayed union and nonunion. It suggests targeting high-risk groups like the elderly. Despite its promising results, this study shows the need for more research to standardise fracture patient nutrition. Further research should examine the optimal supplement dosage and duration and the long-term effects of dietary interventions on bone strength after fracture. Additional micronutrients like magnesium, zinc, and vitamin K could help explain bone healing. Finally, adding targeted nutritional support to orthopaedic treatment may improve fracture healing. We should prioritise routine nutritional assessments, early dietary interventions, and patient education on bone-healthy eating to improve recovery and musculoskeletal health.

Reference

1. Yu, Y., Li, X., Zheng, M., Zhou, L., Zhang, J., Wang, J., & Sun, B. (2024). The potential benefits and mechanisms of protein nutritional intervention on bone health improvement. *Critical Reviews in Food Science and Nutrition*, *64*(18), 6380-6394.
2. Beatarisa, C., & Qaissara, E. (2024). Effect of Vitamin D Supplementation on Bone Fracture Healing: Impact on Healing Rates, Recovery Time, and Functional Recovery. *International Journal on Health and Medical Sciences*, *3*(1), 40-46.
3. Ortona, E., Pagano, M. T., Capossela, L., & Malorni, W. (2023). The role of sex differences in bone health and healing. *Biology*, *12*(7), 993.
4. Wang, L., & Zhang, G. (2024). Analysis of the effect of mini-nutrition nursing plus Baduanjin rehabilitation exercise on fracture healing, mobility and nutritional status of elderly patients with vertebral or hip fractures. *Biotechnology and Genetic Engineering Reviews*, *40*(3), 2508-2519.
5. Reeves, J., Tournier, P., Becquart, P., Carton, R., Tang, Y., Vigilante, A., ... & Habib, S. J. (2024). Rejuvenating aged osteoprogenitors for bone repair. *Elife*, *13*, RP104068.
6. Kondi, S., & Gowda, S. R. (2023). Principles of bone healing. *Surgery (Oxford)*, *41*(10), 625-631.
7. Zandi, R., Razani, H. O., Mehrvar, A., Jowshan, M. R., Sahebkar, A., Nikooyeh, B., ... & Talebi, S. (2024). Effects of trehalose on bone healing, physical function, and pain in patients with pertrochanteric fractures: a randomized controlled trial protocol. *Trials*, *25*(1), 823.
8. Huang, Y., Xu, Y., Huang, Z., Mao, J., Hui, Y., Rui, M., ... & Chen, L. (2024). Melatonin and calcium phosphate crystal-loaded poly (l-lactic acid) porous microspheres reprogram macrophages to improve bone repair. *Journal of Materials Chemistry B*, *12*(30), 7367-7383.
9. Wang, H., Li, X., Xuan, M., Yang, R., Zhang, J., & Chang, J. (2024). Marine biomaterials for sustainable bone regeneration. *Giant*, 100298.
10. Yang, J., Xiao, L., Zhang, L., Luo, G., Ma, Y., Wang, X., & Zhang, Y. (2024). Platelets: a potential factor that offers strategies for promoting bone regeneration. *Tissue Engineering Part B: Reviews*, *30*(6), 631-643.
11. Siddiqui, S. A., Srikanth, S. P., Wu, Y. S., Kalita, T., Ambartsumov, T. G., Tseng, W., ... & Michalek, J. E. (2024). Different types of algae beneficial for bone health in animals and in humans–A review. *Algal Research*, 103593.
12. Sun, W., Ye, B., Chen, S., Zeng, L., Lu, H., Wan, Y., ... & Guo, X. (2023). Neuro–bone tissue engineering: emerging mechanisms, potential strategies, and current challenges. *Bone research*, *11*(1), 65.
13. Ding, Y., Lin, F., & Liang, X. T. (2024). Innovative hydrogel delivery of bone marrow stromal cell-derived exosomes for enhanced bone healing. *World Journal of Stem Cells*, *16*(12), 1106.
14. Batool, I., Altemimi, A. B., Munir, S., Imran, S., Khalid, N., Khan, M. A., ... & Aadil, R. M. (2024). Exploring Flaxseed's potential in enhancing bone health: Unveiling osteo-protective properties. *Journal of Agriculture and Food Research*, *15*, 101018.
15. Alcock, R., Hislop, M., Vidgen, H. A., & Desbrow, B. (2024). Youth and Adolescent Athlete Musculoskeletal Health: Dietary and Nutritional Strategies to Optimise Injury Prevention and

Support Recovery. *Journal of Functional Morphology and Kinesiology*, *9*(4), 221.

16. Rezapour, M., Seymour, R. B., Sims, S. H., Karunakar, M. A., Habet, N., & Gurcan, M. N. (2024). Employing machine learning to enhance fracture recovery insights through gait analysis. *Journal of Orthopaedic Research®*, *42*(8), 1748-1761.]
17. Rahmati, M., Haffner, M., Lee, M. A., Leach, J. K., & Saiz, A. M. (2024). The critical impact of traumatic muscle loss on fracture healing: Basic science and clinical aspects. *Journal of Orthopaedic Research®*, *42*(2), 249-258.