Research Article

Does the nutritional status changes the healing outcome of simple diaphyseal tibial fractures in adults: A prospective cohort study

Sabir Ali¹, Ajai Singh²*, Avinash Agarwal³, Anit Parihar⁴, A A Mahdi⁵ and R. N. Srivastava²

¹Ph.D Scholar, Department of Orthopaedics, King George’s. Medical University, Lucknow, India
²Professor, Department of Orthopaedics, King George’s. Medical University, Lucknow, India
³Associate Professor, Department of Medicine, King George’s. Medical University, Lucknow, India
⁴Associate Professor, Department of Radiology, King George’s. Medical University, Lucknow, India
⁵Professor & Head, Department of Biochemistry, King George’s. Medical University, Lucknow, India

*Correspondence Info:
Prof. Ajai Singh,
Department of Orthopaedics,
King George’s. Medical University, Lucknow, India
Email: as29762@gmail.com

Abstract

Objectives: The main objective of the study was to correlate the healing outcome of the simple diaphyseal fractures with the nutritional status of the patients.

Method: In this longitudinal cohort study, total sixty five adult patients (eighteen to forty-five years) with simple, fresh traumatic diaphyseal fractures of both bones of leg managed conservatively; were analysed. The assessment of nutritional status of enrolled patients was done by estimating serum albumin and serum ferritin at the start of treatment. The clinico-radiological follow-up was done to analyze the fracture healing outcomes. As per clinico-radiological outcomes, these patients were divided into two groups: Group A: clinico-radiological bone healing with RUST score ≥ 7 at or by the end of 06th months (normal healing) and Group B: clinico-radiological bone healing with RUST score < 7 by the end of 06th months (impaired healing). These healing outcomes were correlated with nutritional status of the patients.

Results: Difference between the demographic variables of both groups was statistically insignificant. Fifty four patients belonged to Group A and eleven patients to Group B. Serum albumin and serum ferritin shows non-significant relative risk. However, the serum albumin showed a significant correlation (r = 0.01) with the bony healing progression of diaphyseal tibia.

Conclusions: Impaired nutritional status of the patients having non-significant relative risk with impaired fracture outcomes, but serum albumin showed positive correlation with the bony healing progression of diaphyseal tibial fractures.

Keywords: Serum albumin, Nutrition, Outcomes of tibial fracture, Impaired healing, Nutritional status

1. Introduction

The subcutaneous position of the tibia results in a greater incidence of fractures and less soft-tissue coverage produce a higher incidence of impaired healing⁶. Only the rate of tibial nonunions is estimated to constitute 2-10% of all tibial fractures⁷. Fracture impairment leads to prolonged disability, associated with substantial pain and put extra burden on the patient. Fractures impairment may be caused by several factors such as extensive soft tissue damage, the presence of a gap at the fracture site, poor mechanical stability, open fractures, administration of pharmacological agents, such as NSAIDs and smoking, etc. The potential role of nutritional health in the fracture healing outcomes among individuals also known⁸-¹³. But till now, they are not in use as a prognostic marker, in parallel to clinic-radiological diagnosis.

Serum albumin level of ≥3.5 g/dl and serum ferritin of range between 30-400 ng/mL (male) and 13-150 ng/mL (female) is widely accepted as normal. Some authors have used albumin levels alone as a laboratory indicator for malnutrition in orthopaedic patients. Many studies had been correlated protein depletion with increased mortality and morbidity, wound infection, surgical failure, sepsis as well as impaired fracture union and wound healing⁹, 10, 12, 13. Koval et al. in a study also demonstrated that albumin level of < 3.5 g/dl was predictive of delay of fracture to heal, increased length of hospital stay as well as their mortality rate¹⁰, 13.

Based on above, we planned our study to correlate the fracture healing outcomes with nutritional status of the patients, by taking serum albumin and serum ferritin as a nutritional status indicator.

2. Material and Methods

In this longitudinal cohort study, total 78 adult patients in the age group between 18 to 45 years with simple, fresh (< 7 days) traumatic diaphyseal fractures (42-A1, A2 & A3, as per as AO muller classification) of both bones of leg managed conservatively were included. The exclusion criterion were as follows: age less than 18 yrs and more than 45 yrs, osteoporotic fractures, polytrauma, pathologic fractures, compound or infected fractures, chronic alcoholic or tobacco smokers, immune-compromised patients, patients with intact fibula, uncontrolled diabetes, patients with bile duct obstruction and chronic inflammatory bowel disease, patients on prolonged drugs like anabolic steroids, thiazides, diuretics, hormonal therapy, NSAIDs, calcium, fluorides and immunosuppressive drugs, and those not willing for inclusion in study.

After obtaining ethical clearance (Ref. Code: 57 E.C.M. IIA/P4) from institutional ethical review committee, total 78 patients were included in this study from 2011 to 2013. After the informed consent, demographic data of all enrolled patients was collected. The peripheral blood (2ml) was collected into plain vials under standard aseptic technique at the time of management for the estimation of nutritional status of enrolled patients by measuring their serum albumin (ELITech Clinical System) and serum ferritin (Roche Analyser) levels. These biochemical examinations were performed in duplicates as per as their manual protocol. Our reference value of serum albumin are ≥3.5 g/dl and serum ferritin are between 30-400 ng/mL (male) and 13-150 ng/mL (female) respectively, accepted as normal. All were managed conservatively (reduction setting and above knee plaster were applied under regional / general anesthesia). All were discharged after 24 – 48 hours with a standard advice written on discharge card.
The clinico-radiological examinations of these patients were done at 6th, 10th, 16th, 20th, 24th, weeks. Clinical examination of the fracture site was done for the assessment of skin condition, abnormal mobility (if required), bony tenderness and transmitted movements. Radiological assessment was done using RUST score by taking standard plain radiographs of full length of leg (AP and Lateral views). The radiographic scoring was done by an orthopaedic surgeon and by a radiologist separately and blindly. The average of the two scores was given to each radiograph. No specific treatment of impaired nutritional status was done except diet correction if required.

Based on the above clinico-radiological evaluation, we divided these patients into two groups – Group-A: clinico-radiological bone healing with RUST score ≥ 7 by the end of 06th months (normal healing) and Group-B: clinico-radiological bone healing with RUST score < 7 by the end of 06th months (impaired healing). The clinical bone union was defined as the stage in the healing process when the fracture site was painless (no tenderness), motionless (no abnormal mobility) with presence of transmitted movements. Radiographic bone healing was defined when bony callus was evident on at least 3 cortices in standard AP and Lateral views and with RUST score was greater or equal to 7.

2.1 Statistical analysis

The data were entered in Microsoft Excel and were checked for any inconsistency before analysis. Statistical analysis was performed using SPSS software for Windows program (15.0 version). The continuous variables were evaluated with mean (±SD) or range value when required. For comparison of the means between patient groups, relative risk with its 95% confidence interval and Pearson correlation coefficient was used. A p value less than 0.05 or 0.001 were regarded as significant.

3. Results

Total 78 patients were enrolled in present longitudinal study. Thirteen patients were lost in follow up, so we analysed only 65 patients. According to the clinico-radiological outcomes, these fractures were divided into two groups: Group A (n = 54), with normal bony union and Group B (n = 11), with impaired bony union. Table 1 describes the baseline characteristics of all 65 patients. The difference between these baseline characteristics between two groups was statistically insignificant.

Table-1: Baseline characteristics of the patients

| Characteristics of the patients | n=65 |
|---------------------------------|------|
| Age in years                    | 31(53.20) |
| Male gender, no. (%)            | 58 (89.2) |
| Mode of injury, no. (%)         | 18 (27.7) |
| Site of injury, no. (%)         | 32 (49.2) |
| Right                           | 33 (50.8) |
| Hemoglobin                      | 10.28±1.35 |
| S. albumin                      | 3.60±0.25 |
| S. ferritin                     | 98.30±40.26 |
| RUST score                      | 4.00±0.00 |
| AO type, no. (%)                | 42-A1 22 (33.8) |
|                                | 42-A2 23 (35.4) |
|                                | 42-A3 20 (30.8) |

The baseline sampling was done at 2.07 day (range 1-3). The mean level of serum albumin, ferritin and haemoglobin were 3.60±0.25, 98.30±40.26 and 10.28±1.35 respectively. The healing (RUST score) was higher among the patients of age less than 30 years (n= 34) compared with patient of age 30 years or more (n= 31) (RR=1.04, 95%CI=0.83-1.30, p=0.69), which was statistically insignificant. The healing was 1.18 times higher among males patients than females (RR=1.18, 95%CI=0.73-1.91, p=0.38), which was statistically insignificant. In present study the mode of injury did affect the healing status found to be statically insignificant (p<0.05). The healing was 20% and 11% lower respectively, among the patients whose serum albumin (RR=0.80, 95%CI=0.60-1.07, p=0.08) and serum ferritin (RR=0.89, 95%CI=0.50-1.59, p=0.19) were low at the baseline. However, these were also statistically not significant (see Table 2).

Table-2: Comparison of parameters according to healing status

| Parameters          | No. of patients | Group-A | Group-B | RR (95% CI), p-value |
|---------------------|-----------------|---------|---------|---------------------|
| Serum Albumin       |                 |         |         |                     |
| <3.5 (Abnormal)     | 21 (31.6)       | 15 (71.4) | 6 | 28.6 | 0.80 (0.60-1.07), 0.08 |
| ≥3.5 (Normal)       | 44 (64.4)       | 39 (88.6) | 5 | 11.4 |                     |
| Serum Ferritin      |                 |         |         |                     |
| Abnormal            | 4 (6.1)         | 3 (75.0) | 1 | 25.0 | 0.89 (0.50-1.59), 0.19 |
| Normal              | 61 (89.9)       | 51 (83.6) | 10 | 16.4 |                     |

RR: Relative risk, CI: Confidence interval, Normal: male: 30-400 ng/mL, female: 13-150 ng/mL, abnormal: otherwise

Group-A had the mean RUST score of 11.05 (range 8-12) at the end of 06th months and Group-B had the mean RUST score of 5.91 (range 5-6.5) at the end of 06th months, shows statistically significant difference (see Fig 1). The mean healing time of group-A patients was 12.40±2.05 weeks having RUST score ≥ 7. The correlation between RUST score and serum albumin level was found to be significant whereas there was insignificant correlation between RUST score and serum ferritin levels at all the follow-ups (see Table-3).

Table-3: Correlation coefficient between serum albumin, ferritin and fracture healing progression measured by RUST score.

| Follow-up period (RUST score) | Serum Albumin | Serum Ferritin |
|--------------------------------|---------------|----------------|
| 06 week                        | 0.39, 0.001*  | 0.10, 0.39     |
| 10 week                        | 0.40, 0.001*  | 0.18, 0.13     |
| 16 week                        | 0.40, 0.001*  | 0.16, 0.19     |
| 20 week                        | 0.43, 0.0001* | 0.23, 0.05     |
| 24 week                        | 0.43, 0.0001* | 0.22, 0.07     |

*Significant
4. Discussion

Diaphyseal tibial fractures are common and may lead to substantial burden on patients and the healthcare system. The problem of fracture healing impairment further more common in tibial fractures and challenging for the treating surgeons that worsen the burden of tibia diaphyseal fractures many fold.\textsuperscript{4–6} Many of the factors are responsible for fracture impairment.\textsuperscript{10–11} including nutritional status of the patient.\textsuperscript{12–15} Based on above findings, we planned the study to correlate the tibial fracture healing outcomes with nutritional status by taking serum albumin and serum ferritin as a nutritional status indicator of the patients and hypothesised that the fracture healing outcomes of tibial fractures was significantly associated with these nutritional status parameters of the treating patients.

According to Davis et al.\textsuperscript{15} healing is a continuous process to achieve a bony union. Thus, healing should be measurable. But unfortunately, no clinically validated method to measure healing over time is available to date. Currently, clinical and radiological methods are most commonly used to assess the healing of fractures. Hammet et al.\textsuperscript{17} further described that the probability of correct radiological evaluation of fractures union of the tibia has been shown to be only about 50%. Therefore, radiographic assessment is not a very good method to asses fracture healing, essentially when their clinical outcomes are confusing, a fact borne out by a study on the radiological evaluation of the stage of union in fractures of the tibia\textsuperscript{18}. Thus, the patient will have to suffer for a larger period of time.

Many studies had correlated the nutritional status of patients with hip fracture with fracture healing outcomes.\textsuperscript{19–23} It was shown that impaired nutritional status of these patients was correlated with impaired fracture healing. For the same, the current study is an effort to overcome the issue of early prediction of the outcomes of diaphyseal tibial fractures healing by using a simple laboratory test. So that the proper management or intervention may give to the patients with in time, to relieve the socioeconomic burden of the suffering patients.

As per our knowledge, Dwyer et al.\textsuperscript{15} was the first to studied the association of nutritional status on healing of tibial fractures in humans. In that study, 34 patients with open tibial fracture were followed for 40 weeks. Similar to our result, they also found statistically insignificant association of fracture healing outcomes with nutritional status of the patients. But on other hand, Day et al.\textsuperscript{24}, Einhorn et al.\textsuperscript{25} & Guarniero et al.\textsuperscript{26} found the significant association of nutritional status with tibial fracture healing in rats and concluded that nutrition significantly directs the fracture healing in tibia.

In the present study, we found statistically insignificant association of nutritional status of treating patients with tibial fracture outcomes. Although out of total group A patients (n= 54), 28.6% of fractures showed impaired healing and rest 71.4% patients had normal healing. However, out of 88.6% patients with normal nutritional status, 11.4% showed impaired fracture healing.

So in respect to our obtained result, we observed that malnutrition of these patients was not always predicted to result into impaired bone healing, but serum albumin shows positive correlation with the bony healing progression and outcome of diaphysial tibia. The weakness of the current study is that, a relatively small number of patients were enrolled.

5. Conclusion

The subcutaneous position of the tibia results in a greater incidence of fractures and less soft-tissue coverage produce a higher incidence of impaired healing. In day to day practice, clinical and radiological methods are most commonly used to assess the healing have only 50% accuracy. Moreover, clinicians are unable to identify delayed and non-unions early (only after 10 weeks of starting the treatment one can suspect few cases), hereby increasing the suffering time of the patients. As the potential role of nutritional health in the fracture healing progression among individuals also revels in many studies. We observed that nutritional status of patients with simple diaphyseal tibial fractures shows insignificant relative risk in relation to fracture healing outcomes, but serum albumin shows positive correlation with the bony healing progression of these fractures.

References

1. Praemer A, Furner S, Rice DP. Musculoskeletal conditions in the United States. American Academy of Orthopedic Surgeons (Park Ridge, IL); 1992: vii–199.
2. Bhandari M, Guyatt GH, Swiontkowski MF, Schemitsch EH. Treatment of open fractures of the shaft of the tibia. J Bone Joint Surg Br. 2001; 83(1):62–68.
3. Minoo P, McCarthy JJ, Herzenberg J: Tibial nonunions. http://emedicine, medscap.com/article/1252306-overview. Updated 2009. Accessed 4 April 2011.
4. Reed LK, Mormino MA. Distal tibia nonunions. Foot Ankle Clin. 2008;13(4):725-35.
5. Marsh D. Concepts of fracture union, delayed union, and nonunion. ClinOrthopRelat Res. 1998; 355:S22-30.
6. Sarmiento A, Gersten LM, Sobol PA, Shankwiler JA, Vangsness CT. Tibial shaft fractures treated with functional braces. Experience with 780 fractures. J Bone Joint Surg Br. 1989; 71:602-9.
7. Pheiffer LS, Goulet JA. Delayed unions of the tibia. J Bone Joint Surg (Am). 2006; 88:206-16.
8. Alt V, Donell ST, Chhabra A, Bentley A, Eicher A, Schnettler R: A health economic analysis of the use of rhBMP-2 in gustilo-anderson grade III open tibial fractures for the UK, germany, and france. Injury. 2009, 40(12):1269–1275.
9. Hak DJ, Saleh K. Socioeconomic burden of traumatic tibial fractures: non-union or delayed union. Mescap, 2001. URL: http://www.medscape.org/viewarticle/418523.
10. Brinker MR. Nonunions: evaluation and treatment. In Skeletal Trauma Basic science management and reconstruction. 3rd edition. Philadelphia: Saunders; 2003:507-604.

11. Giannoudis PV, MacDonald DA, Matthews SJ, Smith RM, Furlong AJ, De Boer P. Nonunion of the femoral diaphysis. The influence of reaming and non-steroidal anti-inflammatory drugs. J Bone Joint Surg Br. 2000, 82(5):655-658.

12. Foster MR, Heppenstall RB, Friedenberg ZB, Hoazack WJ. A prospective assessment of nutritional status and complications in patients with fractures of the hip. J Orthop Trauma. 1990; 4:49-57.

13. Day SM, Declerf DH. Reversal of the detrimental effects of chronic protein malnutrition on long bone fracture healing. J Orthop Trauma. 2001; 15:47-53.

14. Amitabh Jitendra Dwyer, Bobby John, Maharaj Krishen Mam, Paul Antony, Rebecca Abraham; Molly Joshi. Relation of Nutritional Status to Healing of Compound Fractures of Long Bones of the Lower Limbs. Orthopedics. 2007; 30(9). 709-12.

15. B.J Davis, P.J Roberts, C.I Moorcroft, M.F Brown, P.B.M Thomas, R.H Wade: Reliability of radiographs in defining union of internally fixed fractures, Injury, 2004; 35(6), 557-561.

16. Burnett R, Horne G, Purdie G. Albumin levels and mortality in patients with hip fractures. N Z Med J 1996; 109: 56-57.

17. Lotz J, Hafner G, Prellwitz W. Reference Study for Ferritin Assays. Kurzmitteilung Clin Lab. 1997; 43(11):993-994.

18. McCloskey E V, Spector T D, Eyres K.S, Fern E D, O'Rourke N, Vasikaran S and Kanis J A. The assessment of vertebral deformity: A method for use in population studies and clinical trials: Osteoporosis International; 1993; 3(3): 138-147.

19. Koval KJ, Maurer SG, Su ET, Aharonoff GB, Zuckerman JD. The effects of nutritional status on outcome after hip fracture. J Orthop Trauma. 1999; 13:164-9.

20. Patterson BM, Cornell CN, Carbone B, Levine B, Chapman D. Protein depletion and metabolic stress in elderly patients who have a fracture of the hip. J Bone Joint Surg Am. 1992; 74:251–260.

21. Van Hoang H, Silverstone FA, Leverentz S, Wolf-Klein GP, Foley CJ. The effect of nutritional status on length of stay in elderly hip fracture patients. J Nutr Health Aging. 1998; 2:159–161.

22. Guarniero R, de Barros Filho TE, Tannuri U, Rodrigues CJ, Rossi JD. Study of fracture healing in protein malnutrition. Rev Paul Med. 1992; 110(2):63-8.