International Journal of Medical Science and Education

An official Publication of Association for Scientific and Medical Education (ASME)

Original Research Article

RADIOLOGICAL EVALUATION OF CALLUS FORMATION IN LONG BONE FRACTURES OF LOWER LIMB TREATED BY VARIOUS METHODS

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Received: 28/09/2017 ***Revised : 01/11/2017*** ***Accepted: 05/11/2017***

ABSTRACT

Background: Fracture healing is different from other tissue healing by the absence of a scar at the healing end. The fracture can heal by primary healing or secondary healing depending on the type of treatment offered. Callus formation is an integral part of secondary fracture healing. **Material and methods**: We Compared the callus tissue formation during healing of tibial diaphyseal fracture treated by the conservative method and intramedullary nailing (IMN). C T Scan is used to take a serial measurement of callus index at fixed intervals and compared between the two groups. **Results:** The onset of callus formation is early in case of conservatives treatment as compared to intramedullary nailing is the most striking feature. Whereas maximum callus formation at 6 months is more in case of intramedullary nailing when compared to conservative groups. **Conclusion :** The appearance of the callus tissue is influenced by intramedullary nailing but growth of callus has more rapid accent in case of IMN group compared to POP group which persisted up to 6 months and at the end of 6 month maximum callus reached was more in Nailing cases. Though number of complication is more in this method of treatment.

Keywords: secondary fracture healing, intramedullary nailing (IMN), periosteum.

INTRODUCTION

Fracture of lower limb bones are among most common fractures. Tibia being the subcutaneous one is more prone to fracture. As a long bone at has both cancellous and cortical bone component where healing occurs by different methods.

How the bone heals, amongst the earliest theories, the theory of Albrecht Haller says bone was deposited from vascular networks around the injured zone **(1)**. Hunter classified the bone repair into four stages consisting of inflammation, soft callus, hard callus. and remodelling **(2)**. Hunter also agreed with Albrecht Haller's theory of bone deposits form vascular networks.

H.L. Duhamel proposed that bone was formed form cambium layer **(3)** of periosteum. Others Like John Belchier and John Goodsir emphasized osteoblasts as main bone healing cells **(4)** and W MacEwen said preservation of periosteum not so relevant in healing. Contrary to them Louis Xavier Ollier Proposed all three

bone marrow, bone and periosteum take part in bone healing.

To be able to heal, the bone must at some point of time be brought to rest relative to one another. This immobilization is brought naturally by muscle spasm and cellular proliferation. Charnley **(5)** pointed out the restrictive effect of the cellular proliferation will be greatest if accumulation occurs external to the bone. So callus has basically two functions immobilization and bony bridging. According to one theory **(6)** the callus tissue arises from the specialized osteoprogenitor cells **(7)** which are present on all endosteal and periosteal surfaces. An alternate theory in its extreme form **(8)** argues that the new tissue arises not from bone but from specialised connective tissue cells in the region of fracture which are induced into osteoblast. other have pointed out that these two theories are not mutually exclusive rather both coexist simultaneously **(9)**

Healing in cancellous bone differs in many ways from that in cortical bone as demonstrated by Charnley and Baker**(10)**

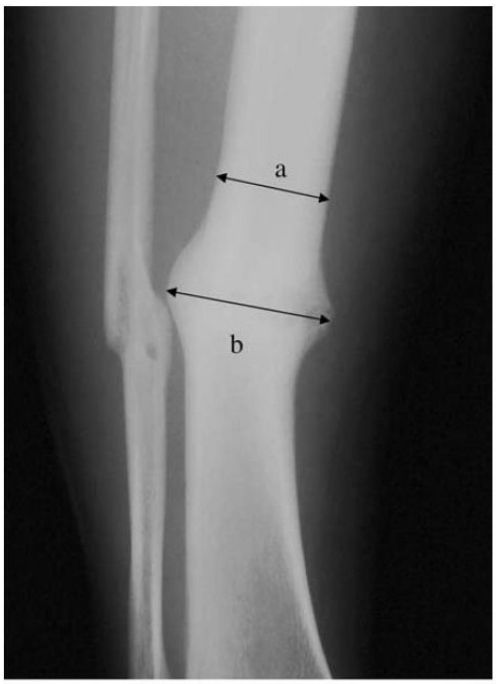
Factors influencing callus formation can be mechanical **(11, 12)**, hormonal **(13)** and Anatomical factors **(5)**. Anatomical factors like distraction has a dramatic effect on the formation of callus and bone healing **(5)**. Rhinelander again described the importance of soft tissthe ue preservation in the healing of fracture **(14)**

With the knowledge of callus formation and effect of stability on it, Newer methods of fracture stabilization invented. Healing under conditions of rigid immobilization modifies the process. Danis in 1949 is the 1st to document this and coined the term 'Soudure autogene' or primary bone healing. it occurs when fracture fragments are reduced anatomically and fixed rigidly **(15)** with participation from periosteum, external soft tissue or bone marrow **(16)**.

Intramedullary nailing ushered new era in treating diaphyseal fractures Nicolaysen in 1897 performed intramedullary nailing of femur **(17)**. Kuntscher in 1939 made it more popular with V-shaped nail **(18)**.

Callus measurement is not the most accurate method of quantification of fracture healing but the presence of callus can be related to the clinical assessment of fracture healing **(19,20)** measuring callus by plain radiographs earlier described by Spencer **(21)**. Oni et al **(22)** measured callus index and calculated callus volume.

Callus index can be described as the ratio of maximum callus diameter to bone diameter at the same level on callus. Plain radiograph's usefulness is limited by interobserver variability of the interpretation **(23).**



Callus Index = b/a

Fig. 1 A diagram of the method used to determine the callus index is shown. The callus index = b/a.

C T Scan with three dimensional reconstruction of the callus seems a better technique to quantify the healing **(24, 25)**.

We have measured the callus index treated by conservative method (POP) and intramedullary Nailing (IMN) of tibial diaphyseal fractures at 1 month, 3month and 6 month using the three dimensional CT Scan. As callus tissue increases with time and reaches a peak before starting of remodeling process, we are able to quantify the callus tissue and comparison between the two groups give an insight to the type of healing process occurring.

MATERIALS AND METHODS

Patients are chosen from the records of operation theatre for intramedullary nailing and from OPD and plaster room for conservative management from department of Orthopedic, Sawai Mansingh Medical College Jaipur. Patients were informed about the study and consent taken. 30 patients for each group were selected. All the participants are within the age limit of 18-60 years. Open fractures are excluded from the study as well those with history of smoking, head injury, psychiatric illness, steroid intake and other medication that has potential interference on bone metabolism. All the fracture are of diaphyseal location.

Patient follow up done and the callus tissue measurement done at 1 month, 3 month and 6 month CT Scan (Philips ingenuity 128 slice) used to measure the callus diameter with help of osiriX software. Digital analyses of the CT excluded interobserver variation . Callus index is measured by dividing maximum callus diameter with the bone diameter at the same level. Both anteroposterior and mediolateral indices documented. Data compilation done using Microsoft excel 2007 software. statistical analysis was done with SPSS, version 21 for Windows statistical software package (SPSS, Inc, Chicago, IL, USA). The categorical data was presented as numbers (percent) and were compared among groups using Chi-square test. The quantitative data was presented as mean and standard deviation and were compared by students t-test. Probability was considered to be significant if less than 0.05.

RESULT

The mean age of the subjects in the POP group is 34.83 and in IMN group was 33.03 with SD of 10.85 and 13.47 respectively. minimum age in both is 18 years and the maximum is 60 years in IMN group and 56 years in conservative groups. More than 75% of the persons are between 18 to 40 years. Total 9 females were included in a study out of which 4 were treated by intramedullary nailing. Road traffic accident is the most common form of injury amounting from 72% up to 77% of cases. 30% of cases in the pop group are BPL which is nearly 1.7 times more than the operative group.

At end of 1 month, None of the intramedullary nailing cases has developed callus both Anteroposterior and mediolateral. Where as at one month POP group has mean Anteroposterior diameter index of 1.02 with SD of 0.02 (P Value 0.0001). Mediolateral callus index for the POP group has a mean of 1.007 with SD 0.02 (P value 0.04). 56 % of the POP group developed measurable callus at end of one month.

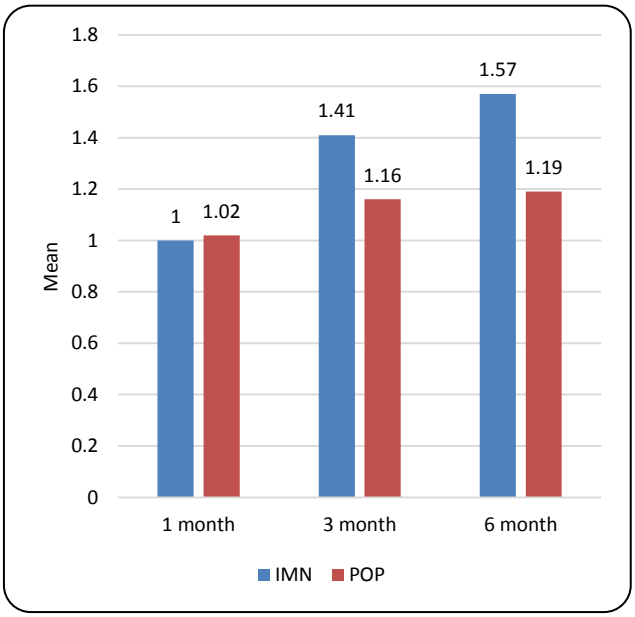
3 months measurements showed 27, IMN group had developed callus with a mean of 1.41 for AP diameter and 1.32 for ML diameter. Mean for POP groups was 1.16 and 1.12 respectively (Both have P-value <0.001). One person has implant failure within 1st two months. Which needed revision surgery.

AP and ML callus index mean at 6 months were 1.19 and 1.14 in a POP group. Same for IMN were 1.57 and 1.52. 2 person with interlocking nail never developed callus within 6 months One has undergone Dynamization.

Comparison of Anteroposterior Callus Index among the group Table 1

	IMN		POP		P value
	Mean	SD	Mean	SD	
1 month	1.00	0.0	1.02	0.02	0.0001
3 month	1.41	0.18	1.16	0.07	p<0.001
6 month	1.57	0.24	1.19	0.06	p<0.001

FIGURE 2



Comparison of Mediolateral Callus Index among the group Table 2

	IMN		POP		P value
	Mean	SD	Mean	SD	
1 month	1.00	0.00	1.007	0.02	0.04
3 month	1.32	0.13	1.12	0.05	p<0.001
6 month	1.52	0.20	1.14	0.06	p<0.001

DISCUSSION

Callus formation occurs in secondary bone healing. Various studies have emphasized the role of periosteum **(3)** and connective tissue **(8)** in the production of this callus. External callus formation it self sufficiently not indicative of healing eg. hypertrophic non-union produces exuberant callus **(26)**. Rather cortical bridging is a better predictor of healing **(27)**.

We chose mostly stable transverse fractures (84%) for conservative management and 66% of the group where with intact fibula. So randomization was not possible from ethical point of view.

Digital image analysis done which improved the accuracy of the measurements **(28)**. Most significant observation at end of 1 month is no nailing case developed callus tissue in comparison to POP group where 56% developed the same. significant difference Anteroposteriorly. (P value 0.0001) but mediolateral measurement have less significant difference in mean.

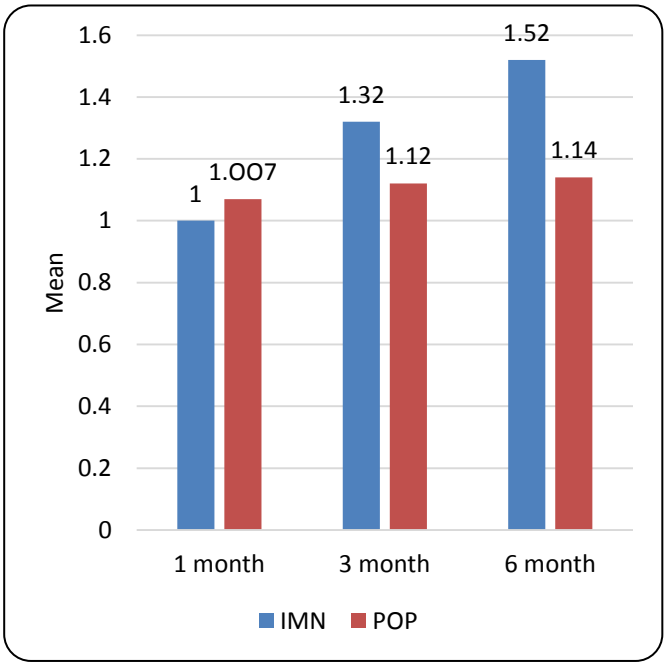
callus tissue formation depends on intact periosteum **(3)** as well as surrounding connective tissue **(8, 9)**, intramedullary nailing destroys the medullary blood supply through periosteum remains intact.

One with nailing had an implant failure within 1st 3 month, Needing revision surgery. Two IMN cases did not develop callus even after end of 3 months. Remaining 27 had well developed callus with mean index 1.41 along AP and 1.32 Mediolaterally which is higher than POP group indices along AP and ML diameter (P-value <0.001) Through intramedullary fixation destroys the endosteal blood supply initially rapid regeneration can occur **(10)**. Low strain environment like too rigid fixation and wide

fracture gap are averse to callus tissue formation **(29)**

All through the observation till end of 6 month we noticed an increase in both AP and ML mean callus formation. Expect two cases where no callus seen. The difference between callus index for POP and IMN at 24 weeks was significant. We can not determine the maximum callus index in both the cases which can be correlated to stat of remodeling **(30)** because callus index never declined. Clearly IMN produced more callus than POP group. Loading and micromotion at the fracture site has profound effect on the callus formation as evidenced by studies **(31,32)**.

FIGURE 3



CONCLUSION

So final analysis of the study showed striking difference in the behaviour of callus tissue between these two procedures. 1st the appearance of the callus tissue is influenced by intramedullary nailing but growth of callus has more rapid accent in case of IMN group compared to POP group which persisted up to 6 months and at the end of 6 month maximum callus reached was more in Nailing cases. Though number of complication is more in this method of treatment.

Our study never compared the healing itself as only presence of external of periosteal callus is not criteria for fracture healing. Rather it proves fixation of fracture by intramedullary device also heals by secondary intention.

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