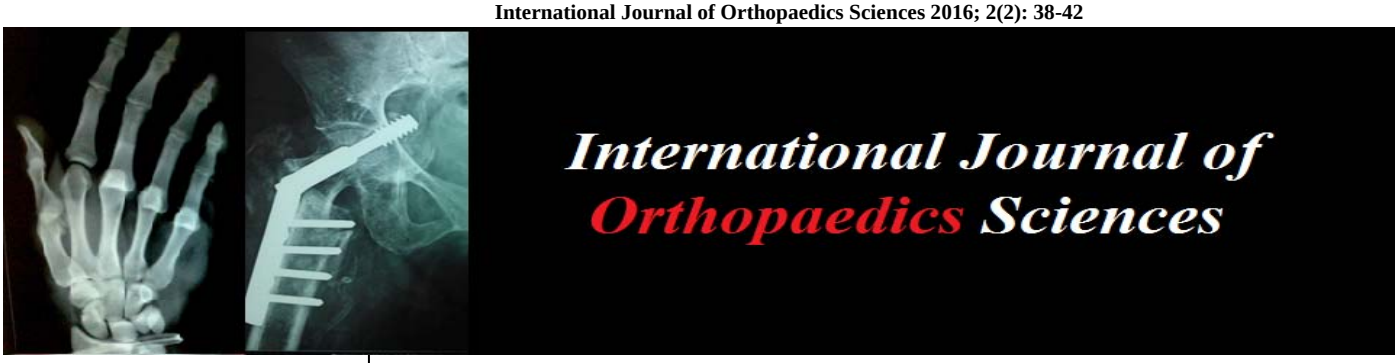

ISSN: 2395-1958
IJOS 2016; 2(2): 38-42

www.orthopaper.com
Received: 19-02-2016
Accepted: 20-03-2016

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Intramedullary fixation of distal tibial fractures around diametaphysis using locked intramedullary cannulated distal tibial nail a prospective study

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Abstract
Purpose: There is no consensus on the best way of managing distal tibia dia-metaphyseal extra-articular fractures. To avoid the complications associated with other methods of fixation in these fractures we used intramedullary cannulated distal tibial nail for fixation, utilizing the advantages of nailing. We evaluated results, complications and mean time of fracture union.
Method: A Prospective study of 26 patients treated with distal tibial nail in distal tibia dia-metaphyseal fractures, closed or open grade I to IIIb reporting within 3 weeks of injury. Grade IIIC open and dia-metaphyseal fractures lying within 2.5 cm from the ankle joint were excluded. Reamed and un-reamed technique of nailing were utilized for closed and open fractures respectively.
Results: Average time of radiological union was 21.04 ± 9.44 weeks. Delayed-union reported in (3 of 26 cases). 25 of 26 cases achieved union without secondary procedure, one case required secondary procedure. Commonest complication was anterior knee pain (42%), valgus deformity was commonest in cases which had Mal-union. 85% of the patients had excellent to good result, one case had poor and 3 had fair result.
Conclusion: Good to excellent results & low complication rate can be achieved by managing all dia-metaphyseal extra-articular fractures of distal tibia, by distal tibial nail with adjunctive fixation of concomitant fibular fractures if involves distal 1/3rd and also have syndesmotic instability.

Keywords: Tibia fracture, intramedullary nail, tibiofibular syndesmosis, malunited fracturesp

1. Introduction
Distal tibial extra-articular fractures are often a result of complex high-energy trauma, which commonly involves associated fibular fractures and soft tissue injury [1]. The lower 1/3rd of tibia is devoid of any muscle attachment and has sparse anterior soft tissue coverage, therefore prone to blister formation after injury and complications like infection, delayed-union, and non-union [2, 3]. Tibial fractures show the highest number of treatment alternatives [4]. Each method has its own indications, advantages and disadvantages [5]. Complex fractures of the distal tibia are difficult to treat [6]. Their proximity to the ankle, make the surgical treatment more complicated than the treatment of diaphyseal tibial fractures [7]. Traditional method of open reduction & rigid internal fixation with a compression plate has fallen into disfavour for treating high energy distal tibial dia-metaphyseal fractures because of poor outcome and high complication rate [8]. Although percutaneous plating is biologically beneficial alternative to traditional plating technique but is technically demanding and requires utilization of fluoroscopy [8]. External fixation method for distal tibial fractures also showed high complications especially pin tract problems, mal-union & non-union.[9] Locked intramedullary nailing is currently considered the treatment of choice for most type I, type II, and type IIIA open and closed tibial shaft fractures [10]. In the last 20 years intramedullary fixation has become the mainstay of treating tibial shaft fractures. Because of its success, the indications have been extended to those of the proximal & distal metaphyseal region [7]. The osteosynthesis of tibial fractures with a locked intramedullary nail is recommended by various authors due to the high union rates, low infection & deformity rates & good functional results [11]. Although different treatment method developed for distal tibia fractures exist, the optimal mode of management is still in debate.

Our study with locked intramedullary cannulated tibial nailing in distal tibial fractures was proposed to prevent the complications associated with other modalities of treatment and to utilize the benefits of intramedullary nailing technique. Limited literature exists regarding the functional recovery following intramedullary nailing in such fractures.

2. Material and Methods

A Prospective study was carried out in 26 skeletally mature patients from August 2009-2012. A total of 36 cases admitted with distal tibial dia-metaphyseal fractures out of which 3 cases with intra-articular extension of fracture, one case with fracture within 2.5 cm from the ankle joint, 2 cases of open grade IIIc fracture, one neglected >3 weeks old fracture, and one high risk patient for anaesthesia were excluded. Two cases were lost from follow-up. The remaining 26 cases were followed up for a period of 2 years and assessed clinically and radiologically for fracture union. Pre-operative approximate size of nail required was determined. Need for fibular fixation was determined pre-operatively, if required was done prior to nailing followed by nailing tibia. Implant characteristics (Table 1, Figure 1). All closed fractures were nailed using reamed technique and open fractures using un-reamed technique. Patient was positioned on fracture-table, knee flexed 90-110°. Traction was applied through calcaneal pin for reduction (Figure 2). Clinical and radiological assessment for union was done on each visit after 1st, 2nd, 3rd, 6th and 9th month of surgery and thereafter for a period of 2 years. Bridging callus on 3 of 4 cortices on antero-posterior and lateral radiographs was considered as united. Delayed union was defined as the absence of clinical and radiological signs of union within 26 weeks. Non-union was defined as absence of clinical and radiological evidence of union within 39 weeks. Results were evaluated as excellent, good, fair and poor on the basis of Johner R, Wruhs S. D criteria [12]. Statistical analysis of data was done using SPSS version 10.0. Numerical variables were reported as mean ± S.D and ordinal variables as percentage. Inter-group comparison for numerical variables were performed using multiple logistic regression to estimate the association. The likelihood χ^2 test and logistic regression was also analysed. $P<0.05$ was considered significant.

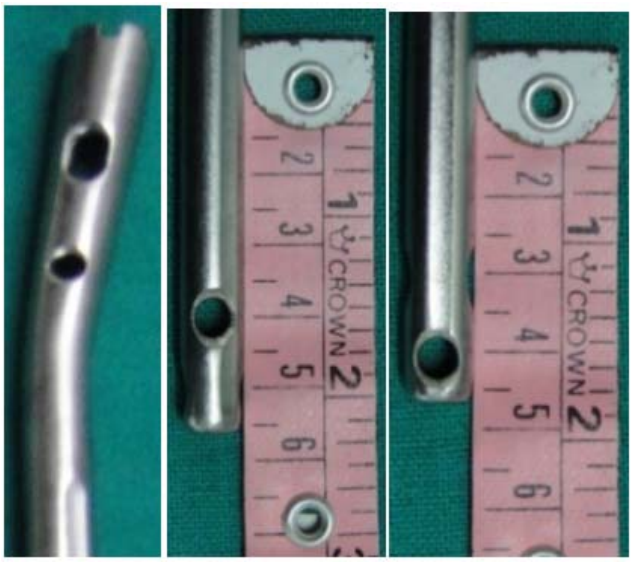


Fig 1: Nail locking options

Table 1

Nail characteristics
Type –cannulated; Herzog bend- 11 degree
Diameter-8,9,10,11 mm Length- 280 to 380 mm (at difference of 10 mm each)
Holes in nail
2 at proximal end proximal- oval, for dynamic locking Distal- circular, for static locking
2 at distal end proximal- circular, medio-lateral at 7 mm from distal tip of nail Distal – circular, antero-lateral at 2 mm from distal tip of nail
1/3rd tubular plate & cortical or cancellous screws
Local implant made of stainless steel was used.

Fig 2: Positioning on fracture table

3. Results

In our study of 26 cases with distal tibial dia-metaphyseal fractures (16 males, 10 females).Mode of injury (RTA-23, fall from stairs-3).23 were closed fractures, in 3 cases (11.54%) of open fractures, 2 were grade2 (42A2) and one case of grade1 (42B3). Commonest fracture pattern was 42B (13 out of 26 cases) followed by 42A (7 out of 26 cases), 2 cases of 42C and 4 cases of 43A type. Statistically significant difference was found on comparison of results in relation to age ($\chi^2 = 20.604$; $p<0.05$) and in relation to Gustilo type of fracture ($\chi^2 =14.841$; $p<0.05$). Statistically non-significant difference on comparison of results in relation to gender ($\chi^2 =1.733$; $p>0.05$), in relation to mode of injury ($\chi^2 =1.717$; $p>0.05$) and in relation to AO classification of fracture ($\chi^2 =21.037$; $p>0.05$) were seen. Concomitant fibular fracture was there in 21 cases (80.77%), 13 in lower 1/3rd, one segmental and 7 in upper 2/3rd but 5 cases had intact fibula. On comparing results in relation to concomitant fibular fracture the difference was statistically non-significant ($\chi^2 =4.727$; $p>0.05$). Fibula was fixed using 1/3rd tubular plate in 4 out of 21 cases (19.05%). These 4 cases had fracture in lower 1/3rd with syndesmotic instability whereas remaining 9 cases of lower 1/3rd fibular fracture had no syndesmotic instability hence were not plated. Upper 2/3rd fibular fractures were also not plated. Average interval between time of injury and time of surgery was 15.31 ± 6.57 hours. On comparison of results in relation to this interval was non-significant ($\chi^2 =8.871$; $p>0.05$) because all cases were operated within 24 hours of injury. Average surgical time was 77.31 ± 10.12 minutes and average hospital stay was 6.19 ± 2.26 days.

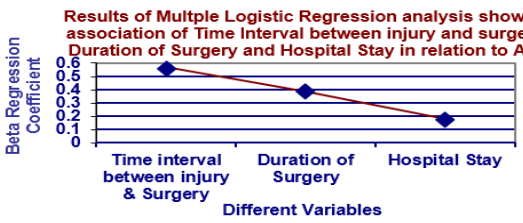


Figure 3

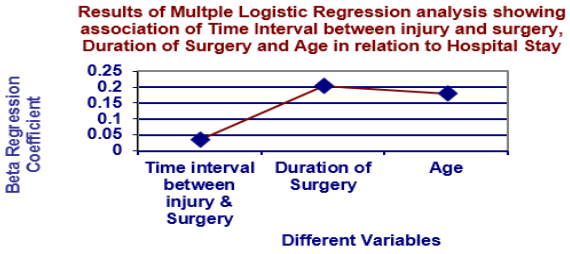


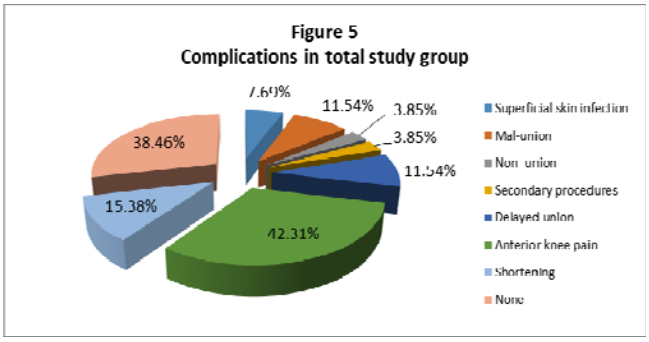
Figure 4

Table 2

Time of radiological union (weeks)	Results								Total	
	Excellent		Good		Fair		Poor			
	No.	%	No.	%	No.	%	No.	%	No.	%
<=14	7	53.8	2	22.2	1	33.3	-	-	10	38.5
15-26	6	46.2	5	55.6	1	33.3	-	-	12	46.2
>26-39	-	-	2	22.2	1	33.3	-	-	3	11.5
>39	-	-	-	-	-	-	1	100	1	3.8
Total	13	100	9	100	3	100	1	100	26	100
χ^2	31.304									
P	0.000									

On comparison of these all results in relation to time of radiological union, the difference was found statistically significant ($\chi^2 = 31.304$; $p<0.05$).

Distribution of cases according to results in relation to time of radiological union (Table 2). In our series 85% (22 of 26 cases) united within 26 weeks of operation. Average radiological union time was approximately 21.04 ± 9.44 weeks. Delayed union was seen in 11% (3 out of 26 patients). One case having valgus 10˚, recurvatum 5˚ and 5˚of external rotation deformity did not unite even after 9 months of primary procedure. It was open grade2 (42A2) type of fracture which united at 12 months after secondary procedure.



Coronal plane deformity was found in 12 cases after surgery. Amongst them Valgus deformity of <10 degrees was present in 10 cases while only 2 cases had deformity ≥ 10 degrees. On comparison of results in relation to coronal plane deformity the difference was found statistically significant (χ^2 =56.127; $p<0.05$). Saggital plane deformity was seen in 8 cases after nailing. Amongst them 2 cases had ≥ 10 degrees of Antecurvatum deformity, 2 with < 10 degrees of Antecurvatum and 4 cases of < 10 degrees of recurvatum deformity were present. On comparison of results in relation to saggital plane deformity the difference was found statistically significant (χ^2 =28.911; $p<0.05$). Only one case in our study had 5 degrees of external rotation deformity and on comparison of results the difference was found statistically significant (χ^2 =26.000; $p<0.05$). Three cases of mal-union were reported. Cases having ≥ 10 degrees of mal-alignment were considered to be mal-united. One case having > 10 degrees of ma-alignment was common in both coronal plane and saggital plane deformity groups. On comparison of results in relation to mal-union, the difference was found statistically significant (χ^2 =10.760; $p<0.05$). None of the cases in our study had any significant shortening. Out of 13 cases of lower 1/3rd fibular fractures those with syndesmotic instability (4 cases) were plated and no shortening was reported in them. In remaining 9 cases without syndesmotic instability fibula was not plated, amongst these 5 cases did not show any shortening but 4 cases had shortening of < 5mm. All patients had full range of movements at knee, ankle and sub-talar joint at 9 months after surgery and at final follow-up after 2 years. 85% of the patients (22 out of 26) were having excellent to good results. There was only one case having poor and three had fair result. (Table 3).

Table 3: (Results evaluated on the basis of Johner R, Wruhs SD criteria).

Result	No. Of patients	Percentage
Excellent	13	50%
Good	9	34.62%
Fair	3	11.54%
Poor	1	3.85%
Total	26	100%

4. Discussion

The optimal way for management of distal tibia fractures is still in debate. Aims of our study were to achieve high union rate, utilize benefits of nailing technique, significantly reduce the hospital stay, early recovery and determine results based on Johner R, Wruhs SD criteria [12]. In our series, the average age of the patients was 37.5 ± 14.66 years (range 18-65 years). George C. Babis [13] *et al* have also reported similar mean age (range 17-85 years). Haydar A.J [14] *et al* and Vallier [15] *et al* both reported the mean age of 38 years in their series. Vallier H.A, T. Toan Le and Asheesh Bedi [16] have reported the mean age of 39.1 years. The pre-operative variables in our study included the patient's age, gender, side of leg injured and time interval between injury & surgery (within 24 hours of injury). We found no statistically significant difference on comparison of results in relation to the pre-operative variables, except the patient's age in which the results were found statistically significant ($\chi^2 = 20.604$; $p<0.05$).

Average surgical time in our study was 77.31± 10.12 minutes ranging from 65 to 100 minutes. In patients where fibula plating was also done in addition to tibia nailing, surgical time was longer (90 to 100 minutes) compared to patients in which only tibia nailing was done. The average duration of surgery in our study was nearly equal to the reported average duration of surgery in Pai Vasu's [6] series of distal third tibia fractures treated by Minimally Invasive Plate Fixation which was 70 minutes (range 45–130 minutes). Contrary to this, the study reported by Guo [17] *et al.* concluded that treating distal metaphyseal fractures of the tibia by closed intramedullary nailing has the advantage of a shorter operating time compared to percutaneous locked compression plate. As the surgical time for nailing and MIP fixation methods are almost similar, it couldn't be considered as a major factor to define superiority of either procedure over the other, so far as the outcome is considered.

Associated fracture of the fibula was present in 80.77% (21 out of 26) cases in our series which is similar to the reported incidence of concomitant fibular fractures in high-energy distal tibial injuries by Teitz C.C, Carter D.R, Frankel V.H [18]. The fibula fractures which were in upper 2/3rd of the bone 33% (7 of 26 cases) and segmental fracture of the fibula (1 case) were left without fixation in our series, 62% (13 out of 21 cases) of the fibula fractures which were in the lower 1/3rd of the bone were assessed clinically to determine whether fibula fixation was required or not, and were treated accordingly. The assessment so done was based on distal tibio-fibular syndesmotic stability. In the present study only 4 out of 13 cases having fracture in the distal 1/3rd of the fibula required fixation. Although the group (that involved Syndesmosis) treated with adjunctive fibular fixation were aligned better than those which were not stabilized. On comparison of results in relation to fibula plating, the difference was found statistically non-significant (χ^2 = 4.727; p>0.05) concluding that favourable clinical outcomes may be achieved without fibular fixation in such cases. This supports the study by Whorton and Henley's [19] retrospective review of 157 tibial fractures with ipsilateral fibular injuries, in which there was no statistically significant differences in final fracture alignment, time to union or number of secondary procedures needed to achieve union between the groups defined by fibula stabilization (all distal fibular fractures that involved the syndesmosis were stabilized) concluding that fibular fixation in the absence of syndesmotic injuries did not affect outcomes of tibial fractures. On reviewing literature, in a study of R. Varsalona, Liu G.T [1] evaluating the role of fibular fixation in distal tibial metaphyseal fractures they concluded "adjunctive fixation of concomitant fibular fractures without associated syndesmotic or ankle pathology is not necessary in surgically stabilized extra-articular metaphyseal fractures of the distal tibia". Although fibular fixation has been shown to improve stability of distal tibial fractures, there has been increased potential for soft tissue-related complications and a delay of tibial fracture healing. This study was in support of the principle we implied for deciding need for fibular fixation in our study.

The average hospital stay in our study was 6.19± 2.26 days which was less than reported by Yip W.H, Lee K.B, Shen W.Y [20] (7.6 days) after metaphyseal plating by minimally invasive plate osteosynthesis. In all the cases the post-operative range of movements at knee, ankle and sub-talar joint were normal at 9 months follow-up. This was because we encouraged first post-operative day mobilisation active and assisted hip, knee, ankle and toe movements. We encouraged partial weight bearing on affected extremity after 6 weeks of surgery and full weight bearing when 3 cortices showed radiological signs of union out of 4 cortices. The union rate in our study was 96% (25 out of 26 cases united without any secondary procedure) which was almost similar to that reported by Court-Brown [21] *et al.* in a series of 125 acute displaced closed and type 1 open fractures treated with reamed nailing. However, the average time of radiological union in our study was more (21.04± 9.44 weeks) compared to that of Court-Brown [21] *et al.* (17 weeks). This disparity can be explained on the anatomical grounds that in Court-Brown [21] *et al.* series the tibial fractures were diaphyseal whereas in this series the cases included were dia-metaphyseal and more so of metaphyseal region. This anatomical site of fracture has a precarious blood supply and limited soft tissue coverage leading to tendency of delayed union and non-union.

The most common complication in our study was the anterior knee pain (42%) similar to Court-Brown [21] (40%), but Keating J.F, Orfaly R, O'Brien P.J [22] reported 57% patients had anterior knee pain. Court-Brown C.M, Gustilo T, Shaw A. D [23] also reported 56.2% incidence of anterior knee pain after intramedullary nailing of the tibia. These reports show significantly higher rates of the anterior knee pain in comparison to our study. The higher incidence of anterior knee pain may be because of the transpatellar tendon approach used to make entry portal for nailing. The etiology of anterior knee pain is multifactorial and requires further study. On comparison of results in relation to anterior knee pain, the difference was found to be statistically non-significant (χ^2 = 4.290; p>0.05) so the fear of anterior knee pain should not hinder the use of Intramedullary nails in the treatment of tibial fractures. Shortening was the 2nd most common complication (15% patients) reported in our study, however, it wasn't significant (All were ‹1cm.) None of the cases with intact fibula or cases in which fibula plating was done showed shortening. Shortening was seen in such cases where more comminution of tibia fracture was present and the fibula was fractured in its lower third or had a segmental type of fracture. Superficial skin infection was reported in 8% of cases in our series which resolved by daily dressings and oral antibiotics for 2 to 3 weeks. Im and Tae [24] reported 3% superficial infection in the nailing group of extra-articular fractures of the distal tibia. The infection rate in our series was higher than reported by Im and Tae [24]. Delayed union reported in our study was 11.54% (3 out of 26). All ultimately united without any secondary procedure.

Fig 6: Pre-op & Post –op radiographs showing fracture union after treatment with distal tibial nail.

Mal-union reported in our series was 11.54% which was significantly more than that reported by Court-Brown [21] *et al.* (2.4%) and P. F Garbuio [25] (3%). This increased rate of mal-union may be attributed to the difficulty in maintaining a good alignment before distal locking of the nail, because the hour glass shape of the intramedullary canal distally, prevents interference fit and compromises self-reduction or if steinmenn's pin in the calcaneus to apply traction through the fracture table is not placed parallel to the ankle joint, prevents the distal fragment alignment before distal locking. All the cases of mal-union in our study were due to mal-alignment of ≥ 10 degrees present in 3 cases (11.54%). The commonest mal-alignment was valgus. Heather A Vallier, T. Toan Le and Asheesh Bedi [16] also reported that valgus is the most common deformity after operative fixation of distal tibia fractures. In our series mal-alignment recorded after operative fixation with nailing on immediate post-operative radiograph did not progress further on the follow-up radiographs and the cases in which well aligned fixation was achieved also did not show any loss of alignment on evaluation of the follow-up radiographs. Always both medio-lateral & antero-posterior dital locking screws should be placed to prevent screw breakage and provide more rotational stability. Partial-weight bearing after 6 weeks of surgery is safe, dynamization if required can also be done by this time.

In our series 84.6% patients obtained good to excellent results (excellent 50%, good 34.62%) which are comparable to the 86.3% satisfactory or excellent results of the series of Tyllinakis [26] *et al.* who treated 73 patients with non-pilon distal tibia fractures using Interlocking Intramedullary nailing. On comparing our study with Pai Vasu [6] *et al.* similar results were observed (TABLE 4).

Table 4

Study	Our study	Pai Vasu *et al.* (2007) [6]
Tibial fracture	Distal dia-metaphyseal	Distal third tibia
Treatment modality	Intramedullary nailing	Minimally invasive plate fixation
No of patients	26	26
Lost follow-up	_	3
Evaluation Criteria	Johner R, Wruhs SD	Johner R, Wruhs SD
Excellent result	13	11
Good result	9	9
Fair result	3	2
Poor result	1	1

Patients with excellent results 50% (13 out of 26) cases in our series, did not have any residual deformity or shortening after nailing. Three cases (11%) in our study had fair result. In order to know what made them place in this category, the analysis of individual patients in this category revealed that one patient had valgus of 10˚ and also antecurvatum of 15˚, the other two patients had valgus deformity of 8˚. One case (4%) in our series had poor result which did not unite until 9 months of surgery, and was taken up for secondary procedure at 9 months. Exchange nailing and bone grafting was done and the fracture united at 52 weeks after injury. The non-union at 9 months in this case was attributed to the open type of the fracture, more comminution in the tibia and poor reduction at the time of primary nailing.

5. Conclusion

High-energy dia-metaphyseal fractures in the lower 1/3rd of tibia can be managed effectively by intramedullary cannulated distal tibial nail with high percentage of good to excellent results and with low complication rates, although it is more technically demanding than nailing diaphyseal tibial fractures. Both closed and open fractures Gustilo I, II, IIIA & B can be managed by this method. Fracture of lower 1/3rd of the fibula should only be fixed if there is a syndesmotic instability, while fracture of the upper 2/3rd does not require any fixation. In patients where fibular plating is required in addition to nailing, it should be done prior to nailing.

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