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Radiological union analysis of femoral shaft aseptic nonunion after failed plate and screw convert to reaming intramedullary solid locking nail

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ABSTRACT

Background: Non-united fracture shaft of the femur after plate fixation is a common problem. Management of this problem is still controversial. There are many methods for treating femoral shaft aseptic nonunions with a broken implant which conversion to reaming solid intramedullary nail is one of the procedures. However, the reported success rate varies. This study aimed to evaluate bone healing, especially callus formation, radiologically after nonunion reconstruction using intramedullary nailing reaming.

Method: This study is a cross-sectional retrospective case analysis presenting 22 patients with the patient's age was 15 to 50 years old who underwent operation procedures managed by removing the hardware and converting to reaming solid intramedullary locking nail with or without autogenous iliac bone graft for at least six months. The bone healing process was assessed by serial plain radiography every six weeks using the Callus Index method.

Results: Conversion to reaming solid intramedullary nailing after nonunion with broken implant gives union rate 95%. Among 22 patients, one patient persisted in nonunion, and two patients experience delayed union. The Callus index of Fracture location (P=0,043) significantly affected index callus formation (P<0.05); The fracture location, whereas fracture classification (P=0,365), nonunion type (P=0,398), and bone graft (P=0,510) did not significantly affect index callus formation (P>0.05). There was no significant difference in time to the solid union between patients with or without iliac autogenous bone graft. Proximal third nonunion affects the time to solid union. No significant complications were noted.

Conclusion: Nonunion reconstruction using solid reaming nail at both types nonunion gives a solid union. Solid union achieves with or without bone graft.

Keywords: Nonunion, Fracture Femur, Reamed Intramedullary Locking Nail, Bone Graft.
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INTRODUCTION

Nonunion fracture in the lower extremity after plating is common in developing countries, including Indonesia.[1] Most medical literature recommends a nail instead of a plate in the acute diaphyseal fracture in the lower extremity.[2] This recommendation is due to a higher rate of the union in nail application. Whereas the nonunion rate in fixation using plate is 8%-19%.[3] In our country, the fracture using plate is relatively inexpensive and available rather than using a nail.

Some options for treatment of nonunion fracture after fixation with plate and screw are available; it can be revised using plates, intramedullary nailing fixation, external fixation, bone graft, or other techniques depending on the circumstances of each case.[4,5] The reaming technique using a solid intramedullary locking nail produces viable bone cells (osteoblasts), which help heal the nonunion.[6] This study determined bone healing, especially callus formation, radiologically after nonunion reconstruction using intramedullary nailing reaming.

MATERIALS AND METHOD

Location and research design

This study was conducted at Dr. Wahidin Sudirohusodo Hospital, which started in November 2013. A retrospective analysis design was used for this study.

Population and samples

This study used all patients who had converted surgery to intramedullary nailing and were selected to meet the inclusion and exclusion criteria. The sampling method was to obtain patient medical data as secondary data and conduct interviews and clinical and radiological examinations as primary data. The data was collected from November 2008 - December 2013. The total sample was 22 patients, had intramedullary nailing surgery for at least six months; the patient's age was 15 to 50 years.

Data collecting method

Data were obtained by recording, identifying patients after intramedullary

nailing surgery in nonunion cases with plating on the femur. Plain radiography was taken every six weeks. Healing was measured with the callus index.

Data analysis

Data was processed, and the results were shown in a narrative, picture, table, or graphic. Statistical analysis used the statistical computer program SPSS.

RESULTS

Fifty-nine patients with aseptic nonunion on the diaphysis of the femur after fixation with plate and screw were recorded during the period November 2007 to May 2013 who underwent conversion surgery to reaming intramedullary locking nail at Dr. Wahidin Sudirohusodo Hospital, Makassar, South Sulawesi. However, only 22 patients met the inclusion criteria of this study (Table 1).

Of 22 cases included in this inclusion criteria, 6 cases (27.3%) were identified with proximal third femoral nonunion fracture, 11 cases (50%) with middle third femoral nonunion fracture, and 5 cases (22.7%) with the third distal femoral nonunion fracture.

The age distribution of patients varied, with the youngest age for conversion surgery to reaming intramedullary nailing was 15 years, and the oldest was 67 years with an average age of 32.3 years.

Of the 22 cases included in this inclusion criteria, 15 cases (68.2%) with atrophy nonunion were identified, 7 cases (31.8%) with hypertrophy nonunion. Then from the secondary data, each radiological analysis of the bone healing results was analyzed, and the results were compared between proximal, medial, and distal fractures.

Of the 22 cases included in this inclusion criteria, 7 cases of type 1, 9 cases of type 2, 5 cases of type 3, and 1 case of type 1 were identified according to the classification of Winquist-Hansen femoral fractures.

The maximum callus index formation in the third proximal group occurred at a mean of 28.8 ± 14.2 weeks (Figure 1). In the third middle group, the maximum callus index formation occurred at a mean of 26.7 ± 5.4 weeks (Figure 2). In the third distal group, the maximum callus index formation occurred at a mean of 23.8 ± 1.7 weeks (Figure 3)

Table 1. Frequency of location of the non-union fracture

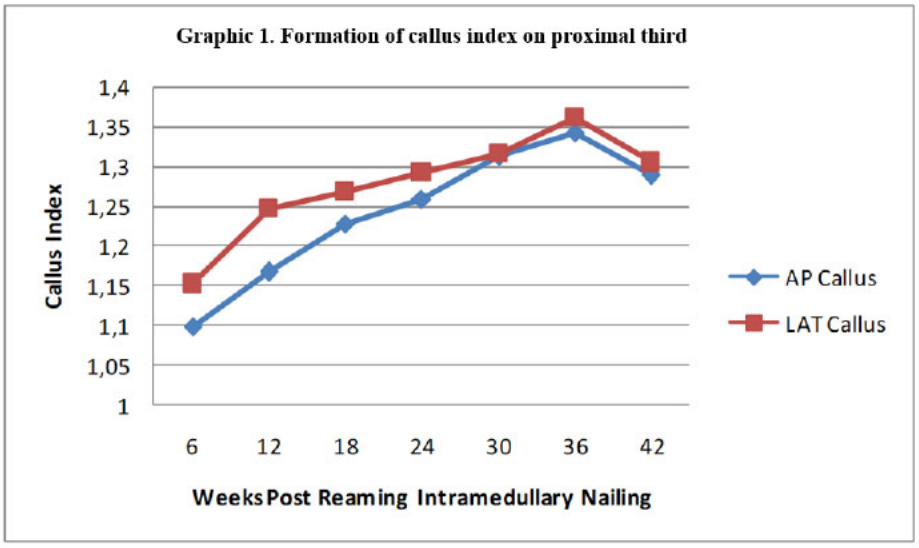
No	Location of fracture	Frequency (%) n = 22
1	Proximal	6 (27,3)
2	Middle	11 (50)
3	Distal	5 (22,7)

Note: n= number of samples

Table 2. Statistical test of maximal callus index.

No	Variable	P-value
1	Callus index – Fracture location	0,043*
2	Callus index – Fracture classification	0,365
3	Callus index – Non-union type	0,398
4	Callus index - Bone Graft	0,510

* Significance if P <0,05



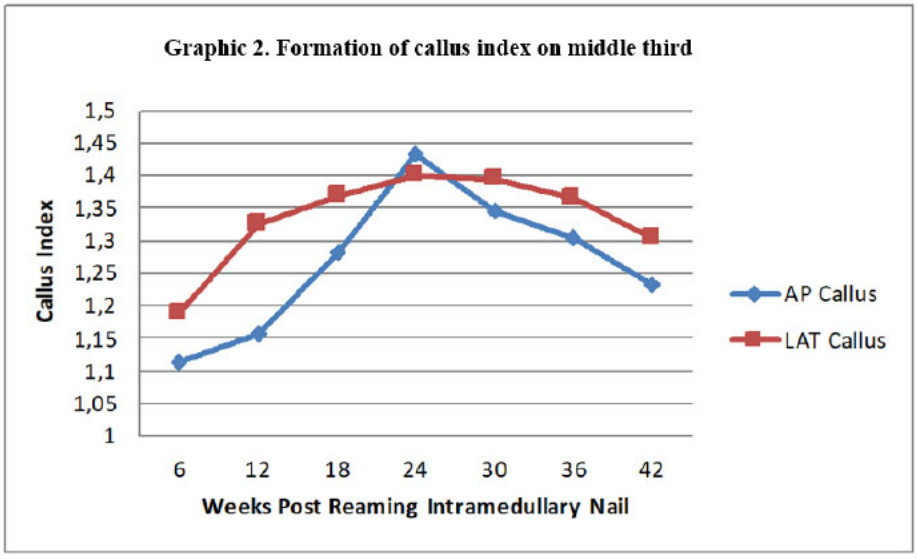
*AP: Anterior-posterior; LAT: lateral

Figure 1. The formation of callus index on proximal third

The value of statistical tests was carried out on the correlation between reaching the maximum callus index and its relationship with fracture location, fracture classification, type of nonunion, and bone graft (Table 2). The Callus index of Fracture location (P 0,043) significantly affected index callus formation (P<0.05); The fracture location, whereas fracture classification (P 0,365), nonunion type (P 0,398), and bone graft (P 0,510) did not significantly affect index callus formation (P>0.05). The results of statistical analysis using the non-parametric test found that the P value was significant if P<0.05.

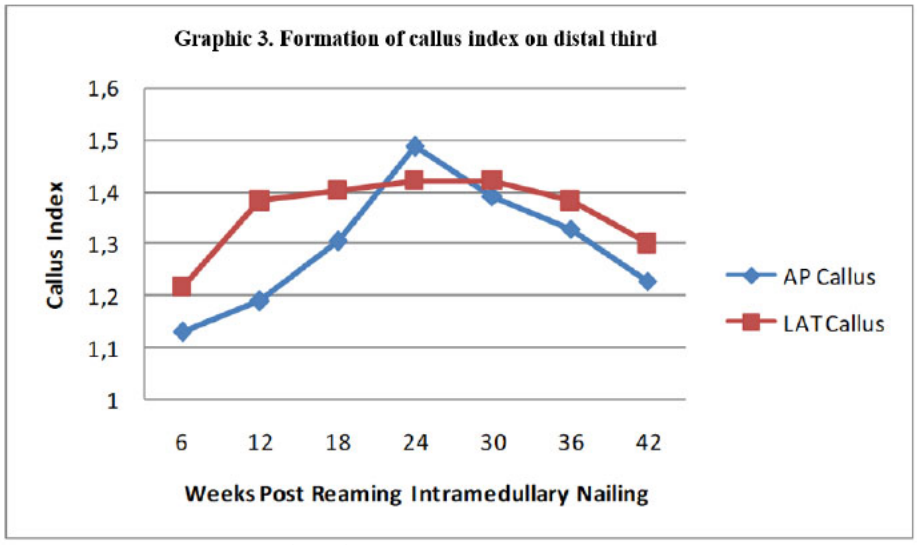
DISCUSSION

This study found that the average healing process in nonunion with broken implants in the femoral diaphysis after surgery using intramedullary nail reaming was 26.4 weeks with solid union formation radiologically. There is a significant difference between the proximal, middle, and distal healing processes from the statistical analysis. One patient had persisted nonunion in the group with proximal fracture, and two patients had delayed union. The average healing time for others was longer, ranging from 28-36 weeks; this is not following the initial data where the frequency of nonunion after



*AP: Anterior-posterior; LAT: lateral

Figure 2. The formation of callus index on middle third



*AP: Anterior-posterior; LAT: lateral

Figure 3. The formation of callus index on distal third

plating was found more in the third middle location. The demographic distribution of femur fractures at Wahidin Sudirohusodo Hospital is mostly found in the middle third. Thus, most of the fractures of the femoral are in the third middle area. In the middle third and distal third fracture groups, the average healing time was nearly the same, about 23-25 weeks. In research previously, it was found that the fracture location did not affect the healing time, where the meantime for healing at the three locations was almost the same, about 24 weeks.[7] The fracture location can affect bone healing because anatomically, the deforming force of the muscles at the proximal to the femur is greater. Besides, three patients who experienced nonunion (1) and delayed union (2) during acute trauma experienced a communitive fracture with surrounding soft tissue damage, and this may cause the nonunion regardless of host factors itself, including a history of smoking. For patients without union and delayed union, dynamization was performed to remove the proximal locking screw from the fracture.[8]

The pattern of fracture affected bone healing, whereby callus formation in fractures with a stable transverse pattern was faster (24 weeks solid union) than those with unstable oblique patterns (30 weeks solid union).[7] In this study, there was no significant difference in radiological bone healing based on the Winquist-Hansen fracture pattern classification. The solid union was achieved at a mean of 24.7 weeks in all four fracture classifications. This study was performed on acute femoral fractures; thus, in post-fracture nonunion reconstruction, it was found that the classification of the fracture pattern did not affect the time to solid union.

Based on the vascularity and osteogenic potential of the nonunion, it is divided into hypertrophy and atrophy. Hypertrophic nonunion has better potential to heal, but nonunion is caused by poor fixation or inadequate stability. In contrast, atrophic nonunion occurs not only because of poor fixation but also because of a lack of osteogenic potential in the fracture area.[9] However, there was no significant difference between bone healing in hypertrophic nonunion and atrophic nonunion in this study, achieving solid union at the mean of 26.8 weeks. A study by Razaq et al. found similar results with the literature: hypertrophic nonunion had better healing potential than unreaming nail procedures.[8] In this study, there was no difference in healing between hypertrophy and atrophy nonunion, possibly due to the presence of intramedullary reaming, where this condition promoted healing of nonunion.

The use of solid intramedullary nailing gives better results than using flexible nails. A study by Beredjiklian et al. found that the percentage of the union was 40% by using flexible intramedullary nailing while the percentage of union using solid nailing was 80%.[10] This result is following this study that found a healing rate of 95%.

In the reconstruction post-nonunion plating, this study found the same results for reconstruction either using a bone graft or without bone graft, achieving solid union at a mean of 24 weeks. Thus bone graft was not required for conversion using intramedullary nail reaming. This result follows the prior study which indicated that it was unnecessary to use bone graft in nonunion reconstruction, both hypertrophy and atrophy nonunion.[11]

The results showed that conversion to

reamed solid interlocking nails effectively achieved union in both hypertrophic and atrophic nonunion cases. This study also supports evidence from the previous literature indicating that the use of nailing stimulated a healing response because of the internal bone graft of the reamed medulla and better mechanical stability construction plate and screw.[12]

The average success rate of nonunion treatment with conversion to reamed interlocking nails was around 53-100%, with a mean solid union at week 24.[13] According to this study, a healing rate of 95% was obtained, achieving solid union at about 24.9 weeks.

In nonunion with broken implants, the periosteal vascularization is considered impaired due to compression of the plate and screw fixed on the periosteal. The controversy is that reaming will disrupt intramedullary vascularization. However, from the existing literature, there is no significant decrease in medulla blood flow by reaming the medulla canal. There is an increase in extraosseous blood flow by reaming, which can revascularize the dominant callus in the reaming interlocking nail fixation. That is a biological advantage for nonunion. In addition to internal bone graft, reaming also provides a favorable biological condition for bone healing.[14]

This study provides an overview of the radiological results of bone healing in nonunion cases with broken implants converted to reaming intramedullary nails that have been carried out by the orthopedics and traumatology department of Universitas Hasanuddin. This study shows a high union rate. The limitation of this study is the small number of samples. For more results, a longer follow-up and evaluation of existing techniques may be necessary.

CONCLUSION AND SUGGESTION

Conversion to reamed interlocking nails in nonunion plate and screw fixation cases is an option that gives better results. With a high union rate, this procedure can be considered an option in treating nonunion cases with broken implants in the femoral.

It is necessary to do further research with a larger sample; thus, better results are obtained. Further analysis needs to be carried out with a longer follow-up by analyzing the correlation between clinical healing and radiological healing and functional outcomes for more meaningful results.

DISCLOSURE

Conflict of Interest

The authors declare that this article has no conflict of interest.

Author Contribution

ACL and MRS contributed to making research concepts and design. ACL and HY contributed to literature search, clinical studies, and experimental studies. LTP contributed to data acquisitions and analysis. All authors contributed to manuscript preparation and editing.

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Ethical Statement

This study has approved with letter number No. 0352/H4.8.4.5.31/PP36-KOMETIK/2014 from Health Research Ethics Committee, Universitas Hasanuddin.

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