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# Reamed *vs.* Unreamed Intramedullary Nailing of Femoral Fractures in the Elderly

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## Abstract

**Introduction:** Intramedullary nailing (IMN) is an established and accepted procedure for the treatment of femoral shaft fracture in patients younger than 65; however, there are few studies regarding the efficacy of IMN on those over 65. Elderly patients have particular challenges, including osteopenia and other medical problems and comorbidities. Therefore, the purpose of this study was to compare reamed versus unreamed IMN, and to determine which of these method yields better results in the elderly.

**Patients and methods:** Between March 2000 and February 2016, we treated 822 femoral shaft fractures, 384 of which underwent IMN. Of these patients, 88 were older than 65, and 72 of these fulfilled our inclusion criteria. Seven patients died within the first 3 months after the injury. The charts of the surviving 65 patients (48 (73.8%) female and 17 (26.2%) male, each with one femoral shaft fracture) were reviewed retrospectively. The average age of the included patients was 73.72 years (65-90), and the average follow up period was 86.3 months (12-183).

**Results:** Of the 65 fractures, 13 (20%) were proximal shaft, 48 (73.8%) were mid-shaft, and 4 (6.2%) were distal shaft. Two (3.1%) of the fractures were open (Gustilo grade 1), the rest were closed. Of the fractures, 29 (44.6%) were treated with reamed IMN, and 36 (55.4%) were treated with unreamed IMN. Non-union was seen in five patients (7.7%). Four patients in the unreamed group and one patient in the reamed group needed a secondary procedure (p=0.028); the nails were changed, and all achieved union. The fractures in the URFN cases took longer to heal (mean 37.76 weeks) than those in the RFN group (27.09 weeks, p=0.022). There were two (3.27%) distal screw breakages in the unreamed group.

**Conclusion:** We recommend using reamed IMN to achieve quicker union and to have better union rates.

**Keywords:** Femoral fracture; Intramedullary nailing; Reamed nailing; Unreamed nailing; Non-union

## Introduction

Intramedullary nailing (IMN) has become the standard treatment for femoral shaft fractures. Often, these fractures result from high energy trauma, and they may be associated with multiple system injuries in adults [1,2].

Kuntscher first reported use of the V-shaped nail in 1940 and suggested the nail should act as an internal splint that created an elastic union with the medullary cavity [3]. Two important techniques were developed and introduced during the 1950's. In 1942, Fischer had reported the use of intramedullary reamers to increase the contact area between the nail and bone, with the hope of improving stability of the fracture [4].

Another currently used technique introduced in the 1950's was the application of interlocking screws to increase stability of the structure. Modny and Bambara introduced the transfixion intramedullary nail in 1953 [5]. Although some progress has been made in nail design in the 1990's, significant developments have came along with the expansion of indications for unreamed and reamed intramedullary nailing. While today's experience with intramedullary fixation for tibial and femur fractures has been quite good, there will most certainly be continue investigations to improve the technique.

There are several clinical trials even randomized controlled studies have been performed the use of IMN for femoral shaft fractures [1,2,6-13], but there are few reports comparing reamed and unreamed IMN in the elderly population [6].

Although there are several persistent concerns regarding the consequences of reaming, reamed IMN is considered the standard method of treatment for femoral fractures. The advantages of reaming include increased biomechanical stability [7], rapid fracture healing [8], and less need for secondary procedures [8,9]. There are also disadvantages of reaming, such high rates of perioperative and postoperative mortality. These high mortality rates are caused by conditions such as air and fat embolism, which are thought to result from both the local and systemic effects of reaming [10]. Proponents of the unreamed nailing technique state that unreamed nails are faster to insert, require less operation time, and have favorable results like bone healing, less blood loss and early mobilization that are comparable to those of reamed nails [11-13].

Elderly patients, especially females, often have cortical thinning and decreased bone mineral density [14]. To our knowledge, no study has compared reamed and unreamed IMN in this age group. This retrospective study aims to compare postoperative outcomes between reamed femoral nailing (RFN) and unreamed femoral nailing (URFN) in elderly patients. Based on the literature, we hypothesized that older patients with RFN will have better postoperative outcomes than those with URFN.

## Materials and Methods

### Study design

We treated 822 femoral shaft fractures in the Department of Ege University Orthopaedics and Traumatology Clinic between March 2000 and February 2016. Of these, 384 underwent IMN; 88 of these patients were older than 65, and 72 fulfilled our inclusion criteria. Seven of these patients died within the first 3 months after the injury. The remaining 65 patients were reviewed retrospectively. Patients were included in the study if they were older than 65 and had a femoral fracture treated with IMN. The definitions and classifications of shaft fractures were based on the Arbeitsgemeinschaft für Osteosynthesefragen/ Orthopaedic Trauma Association (AO/OTA) classification [15], while the Gustilo-Anderson classification was used for open fractures [16]. Patients were excluded from the study if they had pathological fractures or if they had primary treatment with a plate or external fixator. **Figure 1** illustrates the inclusion process.

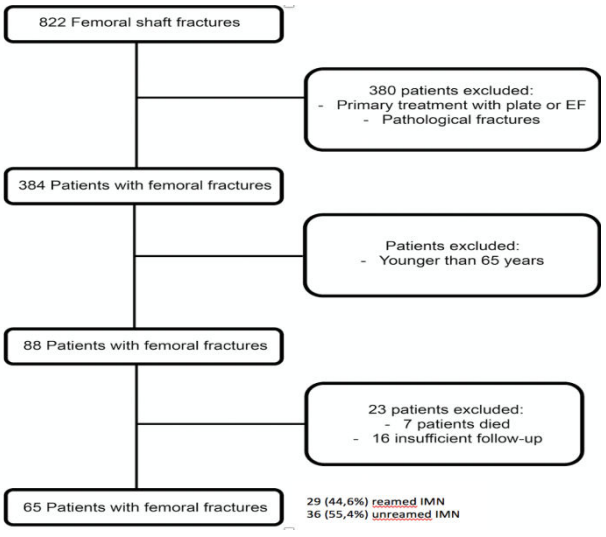


**Figure 1:** Patient inclusion process (EF: External Fixator).

Patient demographics including age, gender, and the American Society of Anesthesiologists (ASA) score were recorded, and are presented in **Table 1**.

Both the RFN and URFN groups underwent similar operating techniques, rehabilitation programs, and postoperative evaluation. A closed antegrade intramedullary nail was placed in all of the patients. Surgeries were performed with a trauma table and flouroscopy within thirteen days of the injury.

Nonunion was defined according to the literature [17,18] both clinically and radiologically as having between 6 and 9 months of non-union in fracture treatment, and no progression towards healing over 3 consecutive months. Surgical fixation was performed using the following three types of nails: unreamed femoral nail (UFN, Depuy Synthes), reamed femoral nail (RFN, Depuy Synthes), and Trochanteric Antegrade Nail (TRIGEN META-TAN, Smith & Nephew).

**Table 1:** Patient demographics.

| Patient demographics | URFN (n=36) | RFN (n=29) | p-value |
|---|---|---|---|
| Age | 73.25 (65-82) | 74.31 (65-90) | NS |
| Gender n (%) | | | NS |
| Male | 12/36 (33.3%) | 5/29 (17.2%) | |
| Female | 24/36 (66.7%) | 24/29 (82.8%) | |
| ASA Score n (%) | | | NS |
| ASA 1 | 5/36 (13.9%) | 2/29 (6.9%) | |
| ASA 2 | 22/36 (61.1%) | 21/29 (72.4%) | |
| ASA 3 | 9/36 (25.0%) | 6/29 (20.7%) | |
| ASA 4 | 0/36 (0.0%) | 0/29 (0.0%) | |
| ASA Score=American Society of Anesthesiologists Score | | | |

### Statistical analysis

Statistical analyses were performed using the IBM SPSS Statistics 21.0 program (IBM SPSS Statistics for Windows, version 21.0, Armonk, NY: IBM Corp.) and the SAS 9.3 program. Values of $p<0.05$ were considered significant. The mean, standard deviation, median, minimum, maximum, frequency, and ratio values were used for descriptive statistics. The Mann-Whitney-U test was used for quantitative variables. Correlations between categorical variables were examined by the Pearson Chi-square test and Fisher's exact probability test. The time to union was assessed by the Kaplan Meier curriculum. Differences within the groups were determined using the log rank test, while the risk ratio was estimated by the cox regression model. Union was estimated by multiple logistic regressions.

## Results

**Table 2:** Fracture characteristics.

| Fracture characteristics | URFN (36) | RFN (29) | p-value |
|---|---|---|---|
| Type of fracture (n, %) | | | NS |
| A1 | 4/36 (11.1%) | 7/29 (24.1%) | |
| A2 | 12/36 (33.3%) | 11/29 (37.9%) | |
| A3 | 7/36 (19.4%) | 3/29 (10.3%) | |
| B1 | 7/36 (19.4%) | 6/29 (20.7%) | |
| B2 | 3/36 (8.3%) | 1/29 (3.4%) | |

| | | | |
|---|---|---|---|
| B3 | 0/36 (0.0%) | 0/29 (0.0%) | |
| C1 | 3/36 (8.3%) | 1/29 (3.4%) | |
| C2 | 0/36 (0.0%) | 0/29 (0.0%) | |
| C3 | 0/36 (0.0%) | 0/29 (0.0%) | |
| Gustilo type | | | NS |
| Grade 1 | 1/36 (2.8%) | 1/29 (3.4%) | |
| Grade 2 | 0/36 (0.0%) | 0/29 (0.0%) | |
| Grade 3 | 0/36 (0.0%) | 0/29 (0.0%) | |
| Site of fracture | | | NS |
| Proximal | 7/36 (19.4%) | 6/29 (20.7%) | |
| Midshaft | 26/36 (72.2%) | 22/29 (75.4%) | |
| Distal | 3/36 (8.3%) | 1/29 (3.4%) | |

Fifty (76.9%) of the fractures were caused by simple fall and 15 (23.1%) by were caused by traffic accident. Following the AO/OTA classification, the fracture types were identified as follows: 11 (16.9%) A1, 23 (35.4%) A2, 10 (15.4%) A3, 13 (20%) B1, 4 (6.2%) B2, and 4 (6.2%) C1. The fractures included 13 (20%) proximal shaft, 48 (73.8%) mid-shaft, and 4 (6.2%) distal shaft. Two (3.2%) fractures were open (Gustilo grade 1), and the rest were closed (**Table 2**). There were 15 (23.1%) patients with multiple injuries and 50 (76.9%) with isolated femoral shaft fractures.

The mean hospitalization period was 12 (4-35) days, while the mean time to surgery was 4 (0-13) days. Eight patients had to stay in the ICU (5 patients with traffic accident, 3 with simple fall). Five of these 8 patents had multiple injuries, and their ICU stay lengths were significantly longer than those with isolated femur fractures. The mean injury severity score (ISS) was 8.98 (3-27).

**Table 3:** Injury profile.

| Injury profile | URFN (32) | RFN (27) | p value |
|---|---|---|---|
| Mechanism | | | NS |
| Fall | 26/36 (72.2%) | 24/29 (82.8%) | |
| Traffic accident | 10/36 (27.8%) | 5/29 (17.2%) | |
| Multiple injured | 8/36 (22.2%) | 7/29 (24.1%) | NS |
| ISS (min-max), (SD) | 9.44 (5-27), (4.687) | 8.41 (3-22), (5.110) | NS |
| Polytrauma | 5/36 (13.9%) | 4/29 (13.8%) | NS |
| ISS=Injury Severity Score, SD=Standard Deviation | | | |

Polytrauma is defined as two or more severe injuries in at least two areas of the body with an ISS ≥ 16 [19]. Nine patients (13.8%) (4 in the reamed group and 5 in the unreamed group) suffered femur fracture as part of poly-trauma injury (ISS>16) (**Table 3**).

**Figure 2** shows a Kaplan-Meier curve for the time to union comparing poly-trauma patients and non-polytrauma patients, there was no significant difference between these patients (p=464).

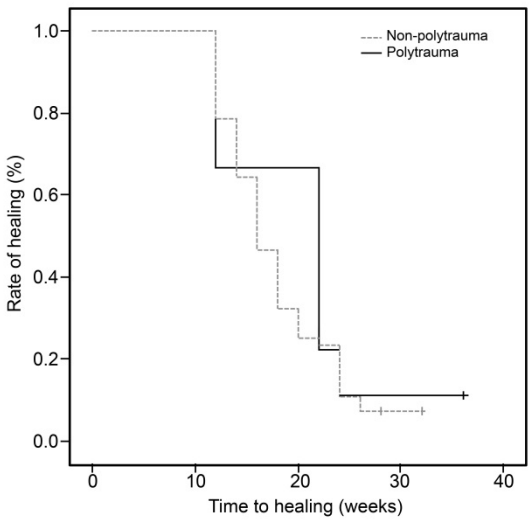


**Figure 2:** Kaplan-Meier curve for the time to union comparing polytrauma patients and non-polytrauma patients.

Patients were divided into two groups: 29 (44.6%) were in Group I (RFN) and 36 (55.4%) were in Group II (URFN). Intraoperative complication occurred in one patient (1.54%) in the unreamed group, in which an iatrogenic fracture of the neck of the ipsilateral femur had to be treated with cannulated screws.

Nonunion was seen in five patients (7.7%), 4 of which were in the unreamed group. Case 1 was a 68 year old male with a closed-type B1 distal fracture. His tobacco use may have negatively affected his bone healing. Case 2 was an 80 year old female with a history of renal and cardiac disease. She had a type B1 midshaft fracture. Case 3 was a 65 year old male with a type C1 proximal shaft fracture. Case 4 was a 72 year old male. He had an A2 midshaft fracture. Case 5 was in the reamed group male. He had a history of diabetes disease. Smoking may have also been a risk factor for nonunion. He had a type A3 midshaft fracture. Of the patients with nonunion, four patients in the unreamed group and one patient in reamed group needed a secondary procedure. The nail was changed in each fracture, and union was achieved in all of them (**Table 4**). The fractures in the URFN group took longer to heal (mean 37.76 weeks) than those in the RFN group (27.09 weeks). The Kaplan-Meier curves in the reamed group for the time to union are presented in **Figure 3**. Reamed femoral nails have significant advantages with regards to union over unreamed femoral nails (p=0.028). We

observed that the fracture type had no effect on union (p=0.574).

**Table 4:** Patients with non-union.

| Patient | Age | Gender | Type of fx | Open/Closed | Side of fx | Tobacco use | Comorbid disease |
|---|---|---|---|---|---|---|---|
| 1 | 68 | M | B1 | Closed | Distal | Yes | No |
| 2 | 80 | F | B1 | Closed | Midshaft | No | Renal and cardiac |
| 3 | 65 | M | C1 | Closed | Proximal | No | No |
| 4 | 72 | M | A2 | Closed | Midshaft | No | Cardiac |
| 5 | 74 | M | A3 | Closed | Midshaft | Yes | Diabetes |

Implant failure was seen in 2 (3.07%) patients; both of these were screw breakages in the unreamed group. Seven patients (10.6%) died during the 3-month follow-up. We believe that these deaths were associated with trauma. **Figures 4 and 5** show the results of the reamed and unreamed femoral nailing cases.

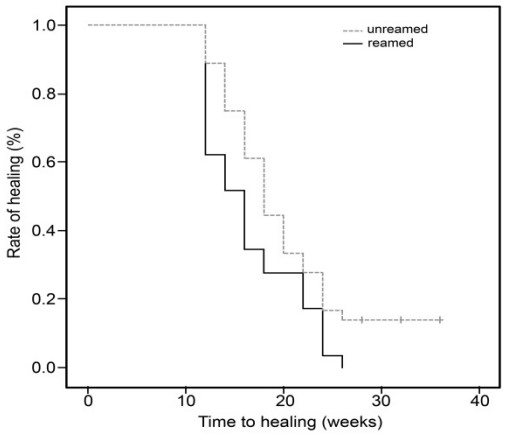


**Figure 3:** Kaplan-Meier curve for the time to union comparing reamed and unreamed nailing.

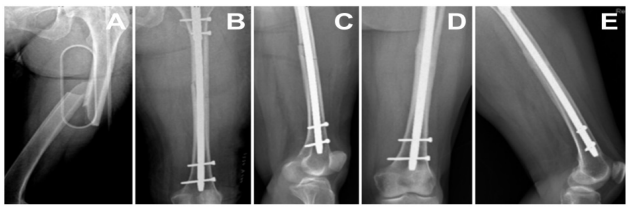


**Figure 4:** (a) 74 year old female sustained 32-A2 femur shaft fracture after simple fall. (b, c) AP-lateral views 2 weeks after reamed nailing. (d,e) AP-lateral views after 12 months showing union.

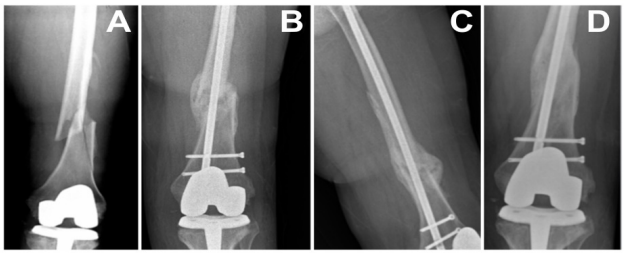


**Figure 5:** (a) 72 year old male with 32-B2 femur distal shaft fracture after traffic accident. (b, c) AP-lateral views 4 months after unreamed femoral nailing. (d) AP view after 12 months showing union.

## Discussion

Femoral shaft fractures are usually the result of high velocity trauma and are more common in the younger population [20]. The pattern of elderly patient fractures is different from that encountered in younger patients. Elderly patients often have low-velocity injuries, usually from a simple fall within the home, which result in oblique or spiral fractures, sometimes with a butterfly fragment.

Comparative studies of reamed and unreamed intramedullary nailing have conflicting results. However, there are few reports about reamed or notreamed intramedullary nailing femoral shaft fractures in elderly patients. To our knowledge, the current study is the first to compare reamed and unreamed intramedullary nailing in this age group.

In 1987, DeMaria [21] reported the benefits of aggressive trauma care in 63 blunt traumatized elderly people. These 63 patients had a moderate level of total injury and a mean ISS of 15.8. Of the patients, 62% had two or more body injuries and 71% had pre-existing cardiovascular disease. In 2009, Maumni et al. published that 66 patients (62%) had multiple injuries. The mean injury severity score (ISS) was 15.6. Forty-two patients (39%) had an ISS ≥ 16. In our current study, the mean ISS was 8.98 (3-27), 15 (23.1%) patients had multiple injuries, and 58 (89.3%) suffered from comorbid disease.

In 1989, Champion and colleagues [22] analyzed data from 3,833 patients aged 65 or older in the Major Trauma Outcome Study (MTOS). They showed that 20.7% of older patients were injured in motor vehicle accidents compared with 40.6% who were injured in falls; 11.7% of the latter group died as a result of their fall. The authors concluded that there is a perception that injury is a disease of the young, which results in a failure to recognize the importance of trauma in the elderly. In their study, Zaki et al. published that trauma was due to 19 falls, 3 traffic accidents and 6 with no injuries [23]. In our current study, 50 (76.9%) patients had a simple fall, while 15 (23.1%) experienced a traffic accident.

Moran et al. reviewed the results of 24 patients who were over the age of 60 and treated with IMN [24]. While they found that IMN was effective in managing femoral shaft fractures, there was a 54% perioperative complication rate. In another study, Asghar concluded that IMN is a valid and acceptable method for the fixation of femoral shaft fractures in the elderly, and they found no significant difference between the outcomes of IMN fixation in patients younger than 60 and those over 60 [25]. In an institution where IMN is the preferred treatment method, Kareeann et al. concluded that older people with atypical and typical femoral fractures have comparable postoperative outcomes [26].

Several studies have been published regarding the use of reaming [11-13,27,28]. In a randomized, prospective study, Clatworthy et al. suggested that reaming aids fracture healing, and that the nail should have a minimum diameter of 12 mm in females and 13 mm in males. In addition, the authors noted that the fractures in the unreamed group were slower to unite (39.4 weeks) than those in the reamed group (28.5 weeks; p=0.007) [8]. Likewise, Tornetta et al. [29] reported that fractures treated with reamed nails healed faster than those treated with unreamed nails, especially distal fractures. In 1998, Zaki et al. found that in elderly femoral fractures treated with URFN, the union rate was 91% (of 28 patients), and there were two delayed unions and two nonunions [23]. Decoster published that there was no nonunion with 16 elderly patients treated with IMN in 2003 [6]. Moumni et al. reported that the incidence of nonunion following unreamed IMN is low (1.9%), and is comparable with the best results of reamed nailing in the literature [28]. Metsemaker et al. concluded that only AO/OTA fracture type correlated with the occurrence of nonunion; the type of fracture reaming did not change the outcome [30]. In our current study, nonunion was seen in five patients (7.7%), and we found that reaming increases the union rate and shortens the union time. In contrast to the study by Metsemaker [30], we found no significant association between fracture type and union rate.

Some studies have shown that embolization of bone marrow contents during reaming can have a detrimental effect on pulmonary function [31,32]. In contrast, other investigators have reported no adverse effects of reaming, even in patients with thoracic trauma [33-36]. In our current study, there were 4 patients with chest trauma; one of them was treated with RIMN, and thus far, this patient did not suffer fat embolism or ARDS.

The reported incidence of infection rate in reamed IMN ranges from 0% to 3.3% [27,37-39], while the rate in unreamed IMN ranges from 0% to 2.9% [40-43]. None of the patients in the current study suffered from infection.

Technically, implant failures include screw or nail failures. Screw failures are more common than nail failures [44]. In 1998, Clatworthy et al. reported 6 implant failures in 48 patients with 50 femoral fractures. Three of these were reamed and three were unreamed [8]. Tornetta reported that unreamed nailing has increased chances for technical complications [29], while Selvakumar reported that 6% of their patients with unreamed nails had implant failures (all screw breakages) in 2001 [45-49]. In their study, Moumni published that there were three (2.8%) implant failures in the unreamed group; two broken nails (one of these broke following a new trauma) and one distal screw breakage [28]. In our current study, 2 patients (3.07%) suffered implant failure. Both of these were screw breakages in the unreamed group.

In their study with 15 elderly patients, DeCoster et al. reported a 26.6% mortality rate [6], while Asghar et al. reported a 14.8% mortality rate in their study with 27 elderly patients [25]. In our current study, there were 7 deaths associated with trauma, and our mortality rate was 10.7%. The mean time to surgery was 4 (0-13) days, and this did not correlate with mortality. Age, gender and ASA score had no effect on union rates, union time and complications.

## Conclusion

Reamed femoral nails have significant advantages with regards to union over unreamed femoral nails. Reamed intramedullary nailing did not increase ARDS, implant failure, or mortality compared to unreamed intramedullary nailing. Based on the results of this study, we recommend using reamed intramedullary nailing to achieve quicker union and to have better union rates.

## Conflict of Interests

The authors declare no conflict of interests.

## References

1. Weiss RJ, Montgomery SM, Al Dabbagh Z, Jansson KA (2009) National data of 6409 Swedish inpatients with femoral shaft fractures: stable incidence between 1998 and 2004. Injury 40: 304-308.
2. Bucholz RW, Jones A (1991) Fractures of the shaft of the femur. J Bone Joint Surg Am 73: 1561-1566.
3. Küntscher G (1940) Die Marknalung von Knochenbruchen. Langenbecks. Arch Klin Chir 200: 443-455.
4. Fischer AW, Maatz R (1942) Weitere Erfahrungen mit der Marknagelung nach Küntscher. Arch Klin Chir 203: 531.
5. Modny MT, Bambara J (1953) The perforated cruciate intramedullary nail: Preliminary report of its use in geriatric patients. J Am Geriatr Soc 1: 579-588.
6. DeCoster TA, Miller RA (2003) Closed Locked Intramedullary Nailing of Femoral Shaft Fractures in the Elderly. Iowa Orthop J 23: 43-45.

7. Kessler SB, Hallfeldt KK, Perren SM (1986) The effects of reaming and intramedullary nailing on fracture healing. Clin Orthop Rel Res 212: 18-25.
8. Clatworthy MG, Clark DI, Gray DH (1998) Reamed vs. unreamed femoral nails. J Bone Joint Surg B 80: 485-489.
9. Canadian Orthopaedic Trauma Society (2003) Nonunion following intramedullary nailing of the femur with andwithout reaming: results of a multicenter randomized clinical Trial. J Bone Joint Surg A 85: 2093-2096.
10. Canadian Orthopaedic Trauma Society (2006) Reamed vs. unreamed intramedullary nailing of the femur: comparison of the rate of ARDS in multiple injured patients. J Orthop Trauma 20: 384-387.
11. Giannoudis PV, Furlong AJ, Macdonald DA (1997) Reamed against unreamed nailing of the femoral diaphysis: a retrospective study of healing time. Injury 28: 15-18.
12. Reynders PA, Broos PL (2000) Healing of closed femoral shaft fractures treated with the AO unreamed femoral nail. A comparative study with the AO reamed femoral nail. Injury 31: 367-371.
13. Shepherd LE, Shean CJ, Gelalis ID (2001) Prospective randomized study of reamed versus unreamed femoral intramedullary nailing: an assessment of procedures. J Orthop Trauma 15: 28-32.
14. Canale ST, Beaty JH (2012) Campbell's operative orthopedics. 12th ed. Philadelphia: Mosby.
15. Müller ME, Nazarian S, Koch P, Schatzker J (1990) The AO classification of fractures of long bones. Berlin/Heidelberg: Springer.
16. Gustilo RB, Anderson JT (1976) Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analysis. J Bone Joint Surg (Am) 58: 453-458.
17. Cleveland KB (2013) Delayed union and nonunion of fractures. In Canale & Beaty: Campbell's Operative Orthopaedics, Volume III. 12th edition. Edited by Canale ST, Beaty JH. Philadelphia: Mosby: Ch.59.
18. Tay WH, de Steiger R, Richardson M, Gruen R, Balogh ZJ (2014) Health outcomes of delayed union and nonunion of femoral and tibial shaft fractures. Injury 45: 1653-1658.
19. Mica L, Rufibach K, Keel M, Trentz O (2013) The risk of early mortality of polytrauma patients associated to ISS, NISS, APACHE II values and prothrombin time. J Trauma Manag Outcomes 7: 6.
20. Bucholz RW (2012) Rockwood and Green's Fractures in Adults: Two Volumes Plus Integrated Content Website; 7th ed. Philadelphia: Lippincott Williams & Wilkins.
21. DeMaria EJ, Kenney PR, Merriam MA (1987) Survival after trauma in geriatric patients. Ann Surg 206: 738-743.
22. Champion HR, Copes WS, Buyer D (1989) Major trauma in geriatric patients. Am J Public Health 79: 1278-1282.
23. Zaki SH, Shamsi S, Butt MS (1998) Femoral fractures in the elderly treated with an unreamed titanium nail. Injury 29: 287-291.
24. Moran CG, Gibson MJ, Cross AT (1990) Intramedullary locking nails for femoral shaft fractures in elderly patients. J Bone Joint Surg 72: 19-22.
25. Elmi A, Rohani AR, Tabrizi A, Esmaili SM (2014) Comparison of Outcome of Femoral Shaft Fracture Fixation with Intramedullary Nail in Elderly Patient and Patients Younger than 60 Years Old. Arch Bone Joint Surg 2: 103-105.
26. Khow KS, Paterson F, Shibu P, Yu SC, Chehade MJ (2017) Outcomes between older adults with atypical and typical femoral fractures are comparable. Injury 48: 394-398.
27. Winquist RA, Hansen Jr ST, Clawson DK (2001) Closed intramedullary nailing of femoral fractures-A report of five hundred and twenty cases-1984. J Bone Joint Surg Am 83: 1912.
28. el Moumni M, Leenhouts PA, ten Duis HJ, Wendt KW (2009) The incidence of nonunion following unreamed intramedullary nailing of femoral shaft fractures. Injury 40: 205-208.
29. Tornetta P, Tiburzi D (1997) The treatment of femoral shaft fractures using intramedullary interlocked nails with and without intramedullary reaming: a preliminary report. J Orthopaed Trauma 11: 89-92.
30. Metsemakers WJ, Roels N, Belmans A, Reynders P, Nijs S (2015) Risk factor for nonunion after intramedullary nailing of femoral shaft fractures: Reaming controversies. Injury 46: 1601-1607.
31. Kropfl A, Davies J, Berger U (1999) Intramedullary pressure and bone marrow fat extravasation in reamed and unreamed femoral nailing. J Orthop Res 17: 261-268.
32. Pape HC, Dwenger A, Regel G (1992) Pulmonary damage after intramedullary femoral nailing in traumatized sheep-is there an effect from different nailing methods? J Trauma 33: 574-581.
33. Bosse MJ, MacKenzie EJ, Riemer BL (1997) Adult respiratory distress syndrome, pneumonia, and mortality following thoracic injury and a femoral fracture treated either with intramedullary nailing with reaming or with a plate-A comparative study. J Bone Joint Surg Am 79: 799-809.
34. Schemitsch EH, Jain R, Turchin DC (1997) Pulmonary effects of fixation of a fracture with a plate compared with intramedullary nailing A canine model of fat embolism and fracture fixation. J Bone Joint Surg Am 79: 984-996.
35. Thoresen BO, Alho A, Ekeland A (1985) Interlocking intramedullary nailing in femoral shaft fractures-A report of forty-eight cases. J Bone Joint Surg Am 67: 1313-1320.
36. van der Made WJ, Smit EJ, van Luyt PA (1996) Intramedullary femoral osteosynthesis: an additional cause of ARDS in multiply injured patients? Injury 27: 391-393.
37. Alho A, Stromsoe K, Ekeland A (1991) Locked intramedullary nailing of femoral shaft fractures. J Trauma 31: 49-59.
38. Wiss DA, Fleming CH, Matta JM (1986) Comminuted and rotationally unstable fractures of the femur treated with an interlocking nail. Clin Orthop Relat Res 212: 35-47.
39. Wolinsky PR, McCarty E, Shyr Y (1999) Reamed intramedullary nailing of the femur: 551 cases. J Trauma 46: 392-399.
40. Abbas D, Faisal M, Butt MS (2000) Unreamed femoral nailing. Injury 31: 711-717.
41. Hammacher ER, van Meeteren MC, van der WC (1998) Improved results in treatment of femoral shaft fractures with the unreamed femoral nail? A multicenter experience. J Trauma 45: 517-521.
42. Krettek C, Rudolf J, Schandelmaier P (1996) Unreamed intramedullary nailing of femoral shaft fractures: operative technique and early clinical experience with the standard locking option. Injury 27: 233-254.
43. Kropfl A, Naglik H, Primavesi C (1995) Unreamed intramedullary nailing of femoral fractures. J Trauma 38: 717-726.

44. Forster MC, Bruce AS, Aster AS (2005) Should the tibia be reamed when nailing? Injury 36: 439-444.

45. Selvakumar K, Saw KY, Fathima M (2001) Comparison study between reamed and unreamed nailing of closed femoral fractures. Med J Malays 56 (suppl D): 24-28.

46. Shim DG, Kwon TY, Lee KB (2017) Rectus FemorisMuscle Atrophy and Recovery Caused by Preoperative Pretibial Traction in Femoral Shaft Fractures-Comparison between Traction Period. Orthop Traumatol Surg Res S1877-0568: 30148-30152.

47. Codesido P, Mejía A, Riego J, Ojeda-Thies C (2017) Subtrochanteric fractures in elderly people treated with intramedullary fixation: quality of life and complications following open reduction and cerclage wiring versus closed reduction. Arch Orthop Trauma Surg (Epub ahead of print).

48. Wakaskar RR, Bathena SP, Tallapaka SB, Ambardekar VV, Gautam N, et al. (2015) Peripherally cross-linking the shell of core-shell polymer micelles decreases premature release of physically loaded combretastatin A4 in whole blood and increases its mean residence time and subsequent potency against primary murine breast tumors after IV administration. Pharm Res 32: 1028-1044.

49. Ambardekar VV, Wakaskar RR, Sharma B, Bowman J, Vayaboury W, et al. (2013) The efficacy of nuclease-resistant Chol-siRNA in primary breast tumors following complexation with PLL-PEG (5K). Biomaterials 34: 4839-4848.