# Non-Union and Avascular Necrosis of Delayed Reduction and Screw Fixation in Displaced Femoral Neck Fracture in Young Adults

Terdtoon Wongwai MD*,
Wiwat Wajanavisit MD**, Patarawan Woratanarat MD, PhD**

** Department of Orthopaedics, Phetchabun General Hospital, Phetchabun, Thailand*
*** Department of Orthopaedics, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand*

***Objective:*** *Management of displaced femoral neck fracture is crucial and vulnerable to develop complications. The present study was performed to evaluate the clinical outcome of delayed reduction with multiple screw fixations in young patients who had displaced femoral neck fracture.*

***Material and Method:*** *The authors conducted a retrospective study in young patients, aged less than 50 years old, who underwent delayed fixation for traumatic displaced femoral neck fracture (Garden classification III or IV) at Phetchabun Hospital between 1997 and 2002. Either closed or open reduction was performed to achieve an acceptable alignment and fixed with 2 or 3 cancellous screws. Study factors were age, gender, Garden classification, time to reduction, type of reduction, number of screw fixation and Garden alignment index. Non-union and avascular necrosis was assessed by clinical and radiographic findings.*

***Results:*** *There were 26 eligible patients. The average duration of delayed surgery was 13 days (range 2 to 30 days). Twenty-three patients had completed followed-up at average 28.4 months (range 14-52 months). All patients revealed complete union and independently ambulated within 10-16 months postoperatively. Clinical and radiographic avascular necroses of the femoral head developed in 2 patients (8.7%) at 20 and 24 months after surgery. Three patients who had early fixation failure underwent hemiarthroplasty except one patient refused to re-operate.*

***Conclusion:*** *Within 30-day delayed reduction and screw fixation for the treatment of displaced femoral neck fracture in the young is still good alternative treatment to preserve the femoral head with low rate of avascular necrosis.*

***Keywords:*** *Femoral neck fractures, Displaced, Delayed reduction, Young adults*

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Displaced femoral neck fracture in the young is one of orthopedic problems, in which the result of treatment is unfavorable[1,2]. It is an emergency condition and requires immediate treatment within 6-12 hours to avoid complications of fracture, including non-union and avascular necrosis of the femoral head[1,3]. Trueta et al[4] reported as high as 85 percent of displaced femoral neck fracture developed avascular necrosis. The management of femoral neck fracture depends on several factors, such as age, status and general condition of the patient, severity of injury, duration of fracture onset and bone quality[1,5,6]. In young adult, the management is early reduction and internal fixation. The successful result of the treatment in this group depends on two factors, immediate anatomical reduction and stable internal fixation[1,7].

According to high rate of avascular necrosis, surgeons are reluctant to fix displaced femoral neck fracture, especially in cases with delayed diagnosis more than 24 hours. Meyer et al[8] recommended an augmentation of quardratus femoris muscle pedicle bone graft in the management of displaced femoral neck fractures, especially in case which surgical treatment was delayed for more than 48 hours[2]. This technique needs an experience and is technically demanding procedure. Some reports concluded that the muscle pedicle graft does not prevent avascular necrosis or even non-union[1,9] and only reduction and femoral neck fixation could provide favorable results[10].

The present study recruited patients who had displaced femoral neck fractures and underwent internal fixation more than 24 hours after injury. Non-union and

***Correspondence to:***
*Wajanavisit W, Department of Orthopaedics,Faculty of Medicine Ramathibodi Hospital, Mahidol University, 270 Rama VI Road, Rajthewee, Bangkok 10400, Thailand.*
*Phone: 0-2201-1589, Fax: 0-2201-1599*
*E-mail: wiwat.waj@mahidol.ac.th*

avascular necrosis of femoral head was observed in both clinical and radiographic features. The results of open vs. closed reduction were also compared to determine the difference between these two methods.

## Material and Method

A retrospective study was conducted at Phetchabun General Hospital during October 1997 to October 2002. Patients, age less than 50 years old, who had displaced femoral neck fracture (Garden III, IV), and underwent delayed surgery later than 24 hours were included. Duration of delayed surgery was defined as the time between the date of onset and the date of operation. All fractures were diagnosed by anteroposterior and lateral radiographs. Patients who had associated condition affecting bone quality such as osteoporosis or metabolic bone disease were excluded.

The operative procedure composed of reduction with multiple screw fixations. A closed reduction was tried initially by using extension traction on fracture table. The satisfactory reduction was evaluated by C-arm fluoroscopy in both anteroposterior and lateral planes using Garden alignment index. In case of unsatisfactory alignment, an open reduction by anterior arthrotomy was performed with an inverted T-incision. The fracture was reduced by direct manipulation. The amount of screw fixation depended on the size of femoral neck and degrees of posterior comminution. Usually 2-3 screws were parallel inserted at the angle of 130 degrees to the femoral shaft. The patient was urged to mobilize as soon as possible, usually within the first week. Non-weight bearing with crutches was prescribed at the second week. The progressive weight bearing was allowed when the radiographic union was revealed, average 10-16 weeks after surgery.

The outcomes of interests were non-union and avascular necrosis. The criteria for non-union were no radiographic sign of fracture healing, persistent hip pain that needed further surgery at 6-12 months, or implant failure. Avascular necrosis was identified by plain radiographs of the hip, either delineating increased bone density or collapse of the femoral head relative to surroundings at least 6 months after surgery.

### *Statistical analysis*

Descriptive analysis was presented as mean and standard deviation (SD) for continuous variables, and percentage for categorical data. The comparison between closed and open reduction group was analyzed by using unpaired t-test and Fisher's exact test. All statistical analysis was performed using STATA 10.0, StataCorp, College Station, Texas. Level of significance was set as less than 0.05.

Sample size calculation was based on alpha error of 0.05, beta error of 0.2, probability to have avascular necrosis in closed reduction group was 15%[11] and the expected avascular necrosis in open reduction in our setting was 25%. The overall sample size was 250 patients per group (Power and Sample Size Program, Vanderbilt, Version 3.0).

## Results

There were 26 patients, 20 males and 6 females, with an average age of 32.2 years (range from 16-50 years). According to causes of fracture, 20 patients (77%) sustained motor vehicle accident and only 6 patients (33%) fell from a height. Seventeen patients (65%) had associated injuries and 13 patients had ipsilateral femoral shaft fracture (Table 1).

Duration of delayed surgery was 2 to 30 days (averaged 13 days). The delay of surgery was due to general condition of the patients, availability of the operating room and operating room personnel and delayed diagnosis, especially in case of multiple injuries. Eight patients could not achieve satisfactory closed reduction and underwent an open reduction of the fracture by Smith Peterson approach with direct manipulation at the fracture. Then, the fracture was fixed with multiple 6.5-mm partially threaded cancellous screws.

Twenty-three patients had complete follow-ups. Average duration of follow-up was 28.4 months (range from 14 to 52 months) (Table 2). All patients ambulated independently within 10-16 weeks postoperatively. Non-union was not presented in any patients (Fig. 1). The other three patients had failure of fixation. Two of them finally underwent hemiarthroplasty and the other refused further operation. Incidence of avascular necrosis of the femoral head was 2 out of 23 patients or 8.7 percent. The first patient (number 17) was 49 years old and fell from a height for 6 days prior to admission. He underwent closed reduction and triple screw fixation. Garden's alignment index was 160 degrees. The radiographs showed avascular necrosis of the femoral head at 20 months after surgery. The other one (number 26) was a 39-year-old man. He sustained a motorcycle accident and had ipsilateral femoral shaft and tibial fractures. He underwent open reduction and triple screw fixation for neglected femoral neck fracture at 30 days after injury. Garden's alignment index was 170 degrees. The

**Table 1.** Demographic data

| No. | Sex | Age (years) | Cause | Duration (days) | Operation | Associated fractures |
|---|---|---|---|---|---|---|
| 1 | M | 44 | Fall | 3 | CRIF with 3 screws | Ulna |
| 2 | M | 45 | MVA | 4 | CRIF with 3 screws | Radius |
| 3 | M | 40 | MVA | 2 | CRIF with 3 screws | Femur, tibia |
| 4 | M | 43 | Fall | 8 | ORIF with 3 screws | - |
| 5 | M | 19 | MVA | 2 | ORIF with 3 screws | - |
| 6 | F | 44 | MVA | 2 | CRIF with 3 screws | Femur |
| 7 | M | 26 | MVA | 20 | ORIF with 3 screws | Femur,tibia |
| 8 | M | 34 | MVA | 2 | CRIF with 3 screws | - |
| 9 | F | 16 | MVA | 15 | CRIF with 2 screws | Femur |
| 10 | F | 33 | Fall | 2 | CRIF with 3 screws | Femur |
| 11 | M | 50 | Fall | 2 | CRIF with 3 screws | Radius |
| 12 | M | 25 | MVA | 30 | ORIF with 3 screws | Femur |
| 13 | F | 50 | MVA | 12 | CRIF with 3 screws | - |
| 14 | M | 25 | MVA | 20 | CRIF with 3 screws | Ulnar |
| 15 | M | 38 | MVA | 15 | CRIF with 3 screws | - |
| 16 | M | 36 | Fall | 2 | CRIF with 3 screws | - |
| 17 | M | 49 | Fall | 6 | CRIF with 3 screws | - |
| 18 | M | 29 | MVA | 14 | CRIF with 2 screws | Femur,tibia |
| 19 | M | 30 | MVA | 19 | CRIF with 3 screws | Femur |
| 20 | M | 26 | MVA | 24 | ORIF with 2 screws | Femur |
| 21 | F | 22 | MVA | 22 | CRIF with 2 screws | - |
| 22 | M | 18 | MVA | 30 | ORIF with 3 screws | Bilat femur |
| 23 | M | 20 | MVA | 20 | CRIF with 3 screws | - |
| 24 | M | 17 | MVA | 30 | ORIF with 3 screws | Femur |
| 25 | F | 20 | MVA | 2 | CRIF with 3 screws | Femur |
| 26 | M | 39 | MVA | 30 | ORIF with 3 screws | Femur, tibia |

CRIF: closed reduction and internal fixation, ORIF: open reduction and internal fixation, MVA: motor vehicle accident

radiographs depicted avascular necrosis of the femoral head at 24 months after surgery (Fig. 2).

When compared the baseline characteristics between patients underwent closed (CRIF) and open reduction (ORIF) in Table 3, the latter group was older, longer duration prior to have surgery, higher percentage of male gender, motorcycle accident and associated femoral fracture than the former group. However, only duration before surgery was significantly longer in ORIF group than CRIF group ($p = 0.0026$). When compared the results between ORIF and CRIF, ORIF group was more likely to have poor Garden alignment index, avascular necrosis and second operation. Nevertheless, these differences did not reach statistically significant level.

## Discussion

It is a consensus that the management of displaced femoral neck fracture in the young is an orthopaedic emergency. Early reduction and stable fixation should be achieved to avoid non-union and avascular necrosis of the femoral head. Major objective of treatment is to preserve blood supply of the femoral head[1,2,12].

The complications directly related to degree of the displacement and time to reduction[1]. According to degree of displacement, there was 16-33% of avascular necrosis in long-term follow-up of displaced fracture[3,11]. The incidence of avascular necrosis reduced to 11% when early fixation was performed[13,14]. For non-displaced fracture, incidence of avascular necrosis was 11-20%[15-17]. From the present study, all patients had Garden III or IV classification and contributed to 8.7% of avascular necrosis after average 28.4 months of follow-up. The higher incidence rate of this complication might be seen at longer follow period. Early reduction and internal fixation within 6-12 hours after injury was claimed to reduce the complication rate[1,7,12]. Swiontkowski et al[7] reported 27 young patients with displaced femoral neck fracture who

**Table 2.** The results of surgery

| No. | Garden alignment index | Second operation | Non-union | AVN | Follow-up |
|---|---|---|---|---|---|
| 1 | NA | 1 m : hemiarthroplasty | NA | NA | NA |
| 2 | 160 L | 4 d : revised screw | - | - | 16 m |
| 3 | 170 R | - | - | - | 17 m |
| 4 | NA | 10 d : hemiarthroplasty | NA | NA | NA |
| 5 | **** | 2 m : implant failure | **** | **** | **** |
| 6 | 140 R | - | - | - | 21 m |
| 7 | 165 R | - | - | - | 22 m |
| 8 | 155 L | - | - | - | 22 m |
| 9 | 160 R | 1 d, revised screw | - | - | 23 m |
| 10 | 155 R | - | - | - | 24 m |
| 11 | 170 L | - | - | - | 23 m |
| 12 | 140 L | - | - | - | 36 m |
| 13 | 190 L | - | - | - | 24 m |
| 14 | 155 L | - | - | - | 26 m |
| 15 | 140 R | - | - | - | 28 m |
| 16 | 160 R | - | - | - | 29 m |
| 17 | 160 R | - | - | + 20 m | 52 m |
| 18 | 155 R | - | - | - | 26 m |
| 19 | 155 R | - | - | - | 30 m |
| 20 | 140 L | - | - | - | 33 m |
| 21 | 165 L | - | - | - | 37 m |
| 22 | 155 R | - | - | - | 37 m |
| 23 | 155 R | - | - | - | 40 m |
| 24 | 155 R | - | - | - | 39 m |
| 25 | 165 R | - | - | - | 14 m |
| 26 | 170 R | - | - | + 24 m | 34 m |

**** no follow-up, refusal of treatment

underwent surgery within 8 hours after injury. Non-union was not found, but avascular necrosis of the femoral head was detected in 5 patients (20%). Tooke et al[3] reported 32 young patients with displaced femoral neck fracture who underwent surgery within 24 hours after injury. The incidence of non-union was 5.5% and avascular necrosis of the femoral head was 33%. From our study, 23 patients who had delayed surgical fixation more than 48 hours and completed at least one year of follow-up, only 2 (8.7%) of them developed avascular necrosis without nonunion. In group which had follow-up for more than 2 years, avascular necrosis occurred in 2 men out of 14 patients (14%). The present results were comparable with early reduction study from previous reports[3,7]. However, two patients who further underwent hemiarthroplasty, and the other one who loss to follow-up might have avascular necrosis. If this worse case-scenario occurs, rate of avascular necrosis (5 out of 26 patients) in the present series would reach 19%.

In the delayed reduction and fixation, the results also depended on operative technique and alignment of reduction[11,12]. A randomized controlled trial found 15% avascular necrosis in closed reduction technique and 19% in open surgery[11]. The present study demonstrated that open reduction were more likely to have avascular necrosis (1 out of 8 patients) when compared to closed technique (1 out of 18 patients). Longer duration from injury to operation in ORIF group may be confounding factor to this finding. The alignment of reduction is another indicator convincing to reduce the complication rate. Garden et al evaluated the alignment of reduction and an acceptable reduction was assessed by alignment index[18-20]. In antero-posterior view of the hip the angle of central axis of medial trabecular system and medial cortex of femoral shaft should be in an acceptable range of 155-180 degrees. From our data, most of the patients achieved acceptable reduction, only 4 patients had varus alignment and the other one had valgus alignment. All of these 5 patients had closed follow-up for more than 2 years without an evidence of

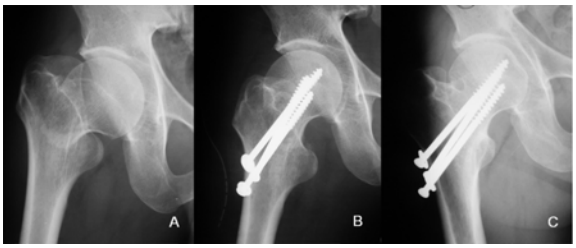


**Fig. 1** Radiographs demonstrated a 40-year-old man (case 3), A, femoral neck fracture of right hip, B, immediate postoperative multiple screws fixation, and C, intact screws with healed fracture and normal femoral head at 17 months of follow-up

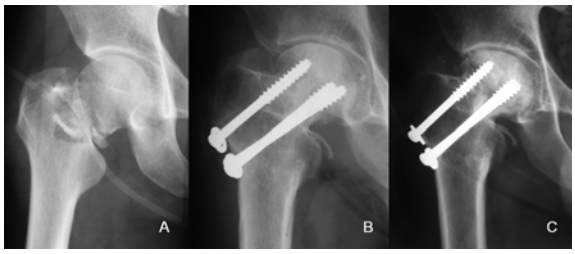


**Fig. 2** Radiographs of a 39-year-old man (case 26) showed A, 30-day-old neglected right femoral neck fracture, B, after multiple screw fixation, and C, he developed avascular necrosis of right femoral head (white head) at 24 months of follow-up

**Table 3.** The comparison of baseline characteristics and results between closed and open reduction

| Variables | CRIF (n = 18) | ORIF (n = 8) | p-value |
|---|---|---|---|
| Age (years), mean ± SD | 34.7 ± 11.1 | 26.6 ± 9.6 | 0.0870 |
| Gender (%) | | | |
| Male | 12 (66.7) | 8 (100) | 0.132 |
| Female | 6 (33.3) | 0 | |
| Cause of injury (%) | | | |
| Fall | 5 (27.8) | 1 (12.5) | 0.628 |
| Motorcycle accident | 13 (72.2) | 7 (87.5) | |
| Duration before surgery (days), mean ± SD | 9.11 ± 7.8 | 21.8 ± 11.1 | 0.0026 |
| Associated fracture (%) | | | |
| Femur | 7 (38.9) | 6 (75.0) | 0.273 |
| Other | 4 (22.2) | 0 | |
| No | 7 (38.9) | 2 (25.0) | |
| Number of screw fixation (%) | | | |
| 3 | 15 (83.3) | 7 (87.5) | 1.000 |
| 2 | 3 (16.7) | 1 (12.5) | |
| Garden alignment index (%) | | | |
| Good | 8 (47.1) | 2 (33.3) | |
| Poor | 9 (52.9) | 4 (66.7) | 0.660 |
| Avascular necrosis (%) | 1 (5.9) | 1 (16.7) | 0.462 |
| Second operation (%) | 3 (16.7) | 2 (25.0) | 0.628 |

radiographic avascular necrosis. No correlation between avascular necrosis and mechanism of injury, duration of delayed surgery or alignment index was found.

Muscle pedical bone graft has been reported to reduce avascular necrosis in delayed femoral neck fracture as low as 0-6%[21-23], 95% union rate and only 5% late segmental collapse. But these results were debated by other studies[9,24]. Nonunion rate was high up to 15%[9,24] and late segmental collapse was 23%[9]. The results from the present study, without muscle pedical bone graft, showed higher avascular necrosis rate with 3 out of 26 late segmental collapses without nonunion. Therefore, muscle pedical bone graft might be superior in terms of low risk of avascular necrosis but late segmental collapse and nonunion has to be more concern.

Risk of early displacement was high during the first 6 weeks after surgery. The main factor was posterior angulation due to unstable posterior comminution of femoral neck[11]. Non-union was associated with posterior comminution of the femoral neck and a quality of reduction, but had non-significant relationship with delayed reduction after 48 hours. The authors revealed three patients who had failed the first screw fixation and needed to have further operation. The displacement developed within 2 months postoperatively. However, posterior comminution could

be not identified and none of our patient had nonunion. All of them can independently ambulate within 10-16 weeks after surgery.

The present study was based on a 500-bed hospital setting in Phetchabun Province. The limitations of the present study are a retrospective non-randomized controlled trial that could face selection bias, recall bias, and measurement bias. Data came from our old cohort started in 1997 and might not be up-to-date. However, the authors were strict on the surgical procedure that is stills used until now. There was no comparison group of quadratus femoris pedicle bone graft. Inadequate sample size to detect clinical and statistical significance is another issue of concern. Long-term of follow-up is still needed to demonstrate the real incidence of complications.

In conclusion, the present study had shown the complications of displaced femoral neck fracture in the young were not as high as previously described in literature, even in the case of delayed surgery for more than 24 hours. It may not be necessary to perform a quadratus femoris muscle pedicle bone graft or primary hip arthroplasty. Simple technique of reduction on fracture table to achieve an acceptable reduction and fixation with at least two screws provide a satisfactory outcome in average 13 months of follow-up. A large-scaled long-term follow-up randomized controlled trial of femoral neck fracture among young adults is still required to find factors related to complications, especially duration to operation and operative technique.

**Potential conflicts of interest**

None.

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## *ผลการรักษาคอกระดูกต้นขาหักชนิดเคลื่อนที่โดยการจัดกระดูกล่าช้าและตรึงด้วยสกรูในผู้ใหญ่อายุน้อย*

*เทอดทูน ว่องไว, วิวัฒน์ วจนะวิศิษฐ, ภัทรวัณย์ วรธนารัตน์*

***วัตถุประสงค์**: การรักษาคอกระดูกต้นขาหักมีความสำคัญและเสี่ยงต่อการเกิดภาวะแทรกซ้อน การศึกษานี้ดำเนินการเพื่อประเมินผลการรักษาทางคลินิกของการจัดกระดูกล่าช้าด้วยสกรูในผู้ป่วยอายุน้อยที่มีคอกระดูกต้นขาหัก*

***วัสดุและวิธีการ**: ทำการศึกษาย้อนหลังในผู้ป่วยอายุน้อยกว่า 50 ปี ที่ได้รับการตรึงกระดูกเพื่อรักษาการบาดเจ็บต่อคอกระดูกต้นขา (Garden classification III หรือ IV) ในโรงพยาบาลเพชรบูรณ์ระหว่างปี พ.ศ. 2540-2545 โดยได้รับการจัดกระดูกชนิด closed หรือ open และยึดด้วยสกรูชนิด cancellous 2-3 ตัว ปัจจัยที่ศึกษาประกอบด้วย อายุ เพศ Garden classification ระยะเวลาก่อนที่จะทำการจัดกระดูก ชนิดของการจัดกระดูก จำนวนสกรู และ Garden alignment index สำหรับการประเมินกระดูกไม่ติดและกระดูกตายจากการขาดเลือดใช้ลักษณะทางคลินิกและภาพรังสี*

***ผลการศึกษา**: ผู้ป่วยจำนวน 26 ราย ตรงตามเกณฑ์การเข้าร่วมการวิจัย ผู้ป่วยจำนวน 3 ราย พบการตรึงกระดูกล้มเหลวและคัดออกจากการศึกษา ระยะเวลาเฉลี่ยของการผ่าตัดล่าช้าเท่ากับ 13 วัน (พิสัย 2-13 วัน) ผู้ป่วยจำนวน 23 ราย ได้รับการติดตามผลการรักษาครบถ้วนเฉลี่ย 28.4 เดือน (พิสัย 14-52 เดือน) ผู้ป่วยทุกรายพบว่ามีกระดูกติดสมบูรณ์และเคลื่อนไหวได้ด้วยตนเองภายใน 10-16 เดือนหลังการผ่าตัด ภาวะหัวกระดูกต้นขาตายที่พบทางคลินิกและภาพรังสีพบในผู้ป่วย 2 ราย (ร้อยละ 8.7) เมื่อติดตามผลการรักษาที่เวลา 20 และ 24 เดือนหลังผ่าตัด ผู้ป่วยที่พบการยึดตรึงล้มเหลวแต่แรกได้รับการผ่าตัดเปลี่ยนหัวกระดูกสะโพก ยกเว้นผู้ป่วย 1 ราย ปฏิเสธการผ่าตัด*

***สรุป**: การจัดกระดูกล่าช้าภายในระยะเวลา 30 วัน และตรึงด้วยสกรูในการรักษาคอกระดูกต้นขาหักในผู้ใหญ่อายุน้อยถือเป็นทางเลือกในการรักษาที่ดี สามารถสงวนหัวกระดูกสะโพกและมีอัตราภาวะกระดูกตายจากการขาดเลือดต่ำ*