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대퇴 경부 골절 환자에서의 내고정술 실패의 위험 요인에 대한 고찰

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Risk Factors of Fixation Failure in Femoral Neck Fractures

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Purpose: Internal fixation after a femoral neck fracture (FNF) is one of the conventional treatment options for the young and active elderly patients. However, fixation failure of internal fixation is a probable complication. The treatment of fixation failure after a primary internal fixation of the FNF remains a challenge.

Materials and Methods: Between July 2002 and March 2017, 83 patients who underwent internal fixation after FNF were retrospectively analyzed. Radiological assessments, including Pauwels' angle, fracture level, reduction quality, and bone union, were measured, preoperatively and postoperatively. Moreover, intraoperative variables such as time to surgery, surgical time, and estimated blood loss were also evaluated.

Results: The patients were divided into the fixation failure and the non-failure groups. Among the 83 patients, 17 cases (20.5%) of fixation failure after the primary internal fixation of the FNF were identified. When comparing the two groups according to the radiographic data, Pauwels' angle and the reduction quality based on Garden's angle showed significant differences ($p<0.001$). Moreover, when comparing the intraoperative variables, unlike the surgical time and estimated blood loss, significant differences were noted in the time interval from injury to surgery and specifically in whether the surgery was performed within 12 hours after injury ($p<0.001$).

Conclusion: Pauwels' angle, reduction quality, and time to surgery are the major factors that can predict the possibility of internal fixation failure of the FNF. Early and accurate anatomical reduction is needed to decrease complications after the internal fixation of the FNF.

Key Words: Femur neck fracture, Internal fracture fixation, Internal failure of fracture fixation, Pauwels' angle, Time to surgery

Introduction

Despite the favorable success rates of surgical procedures for various types of hip fractures, treatment of femoral neck fracture (FNF) can be a burden to surgeons, as the fracture itself is associated with many complications such as osteonecrosis of the femoral head, loss of reduction, malunion, and nonunion.[1-3] Moreover, the treatment remains challenging when fixation failure occurs after primary internal fixation of FNF. In young patients with FNF, internal fixa-

tion with cannulated compression screw (CCS) or dynamic hip screw (DHS) showed favorable results and could be a treatment of choice.[4] However, in the elderly patients, internal fixation showed unsatisfactory results in some studies and other studies reported that arthroplasty is favored for patients over 60 years of age with displaced FNF.[5-8] Although patient's age, initial degree of displacement, timing of fixation, reduction quality, and reduction methods are established risk factors for failure in internal fixation of hip fractures, the risk of failure of internal fixation, particularly after FNF, has yet to be widely reported.[7-10] Hence, in this study, we tried to identify the risk factors for internal fixation failure after FNF.

Materials and Methods

This study was approved by the Institutional Research Ethics Committee at Dankook University Hospital (approval No. 2023-04-014) and the informed consent was waived by the Institutional Research Ethics Committee. Eighty-three patients who were diagnosed with FNF and underwent internal fixation between July 2002 and March 2017 at our center were analyzed retrospectively. Among the patients who were diagnosed as FNF and took the internal fixation, anyone who diagnosed as pathologic fractures, previous fracture history of lower extremity and had less than one year of follow-up period were excluded. Among FNF patients, Garden type 1 and 2 fracture patients were operated with CCS and Garden type 3 and 4 fracture patients were operated with DHS.[5]

Furthermore, in this study, we arbitrarily classified failure after internal fixation of the FNF as follow our radiographic criteria: (1) loss of reduction, (2) nonunion. Loss of reduction was defined when reduced fracture fragment or fixation devices was displaced on radiographic examination. Nonunion was defined when three of four cortices of the fracture site had not shown continuity over six months on plain radiographs.

1. Surgical protocol

Patients were placed in the supine position using a standard fracture table under general or spinal anesthesia. Following closed reduction under image intensifier control, either CCS (TDM) or DHS (Depuy-Synthes, Warsaw, IN, USA) was selected for the internal fixation through a standard lateral approach. After the surgery, hip compression dressing was applied for one week. Non-weight bearing was maintained for the first one weeks. After that, partial-weight bearing to the full-weight bearing of the affected leg was gradually started.

2. Assessment of outcomes

Radiographic assessments were performed preoperatively and postoperatively. Preoperatively, the anteroposterior (AP) and trans-lateral decubitus plain radiographs of the hip were taken and the Pauwels' angle was also measured. After the surgery, radiographic assessments were performed every month for the first three months, followed by every three months for the nine months. The reduction quality was evaluated by measuring the Garden's angle.[11,12] As the Garden[11] mentioned, the anatomical reduction was defined as the Garden's angle which ranged between 155° and 180°, and the mal-reduction was defined less than 155° or more than 180° in both the hip AP and trans-lateral decubitus plain radiographs. Moreover, avascular necrosis (AVN) was diagnosed via imaging studies such as plain radiographs based on the Ficat classification and magnetic resonance imaging.[13]

3. Statistical analysis

The chi-square test was used to analyze the differences in the demographic parameters between the internal fixation non-failure and failure groups. To test the assumption of normal distribution and homogeneity of variance, the independent t-test and Kolmogorov-Smirnov test were performed. All statistical analyses were performed using IBM SPSS Statistics (ver. 25.0; IBM, Armonk, NY, USA).

Statistical significance was set at $p<0.05$.

Results

A total of 83 patients were selected on the basis of the inclusion and exclusion criteria of this study and the mean follow-up duration was 17.0±2.2 months. No significant differences were observed between the two groups (internal fixation failure group vs. internal fixation non-failure group) in terms of the demographic data including age, follow-up duration, sex, location of the fracture in the hip, height, weight, body mass index, mechanism of injury, fixation method, and smoking status (Table 1). Among the 83 patients, 17 patients (20.5%) were defined as failure of internal fixation. During the follow-up, six patients (7.2%) showed loss of reduction and they were gradually progressed to varus hip resulting in post-traumatic arthritis. Eventually, they underwent total hip arthroplasty (THA) one year after surgery. Three patients (3.6%) were identified as having nonunion and underwent THA one year after surgery. Eight patients (9.6%) who showed loss of reduction were additionally diagnosed with AVN. Among them, four patients underwent THA, while the rest were decided to conservative treatment as patients' request. When comparing the two groups according to the radiographic data, Pauwels' angle and reduction quality showed significant differences, respectively ($p<0.001$; $p<0.001$) (Fig. 1). However, fracture level did not show the significant difference (Table 2). Furthermore, unlike the surgical time and estimated blood loss, significant difference was noted in the time interval from injury to surgery, especially whether surgery was performed within 12 hours after injury ($p<0.001$; Table 3) (Fig. 2).

Table 1. Demographics of the Fixation Failure and the Non-Failure Groups Suffering Femoral Neck Fractures

Variable	Failure group	Non-failure group	p-value
No. of patients (%)	17 (20.5)	66 (79.5)	
Age (yr)	54.8±12.1	51.7±13.7	0.615
F/U duration (mo)	19.0±2.4	17.0±2.2	0.752
Sex			
Male	10 (58.8)	34 (51.5)	0.532
Female	7 (41.2)	32 (48.5)	0.072
Affected side			
Right	8 (47.1)	36 (54.5)	0.078
Left	9 (52.9)	30 (45.5)	0.128
Height (cm)	166.6±7.5	166.7±10.9	0.956
Weight (kg)	70.2±14.8	68.1±12.2	0.748
Body mass index (kg/m^2)	25.8±10.2	24.5±4.0	0.762
Mechanism of injury			
Slipped down	8 (47.1)	50 (75.7)	0.062
TA	4 (23.5)	5 (7.6)	0.124
Fall from height	5 (29.4)	11 (16.7)	0.241
Fixation method			
CCS	13 (76.5)	52 (78.8)	0.088
DHS	4 (23.5)	14 (21.2)	0.114
Smoking status			
Non-smoker	13 (76.5)	52 (78.8)	0.089
Smoker	4 (23.5)	14 (21.2)	0.092

Values are presented as number (%) or mean±standard deviation. F/U: follow-up, TA: traffic accident, CCS: cannulated compression screw, DHS: dynamic hip screw.

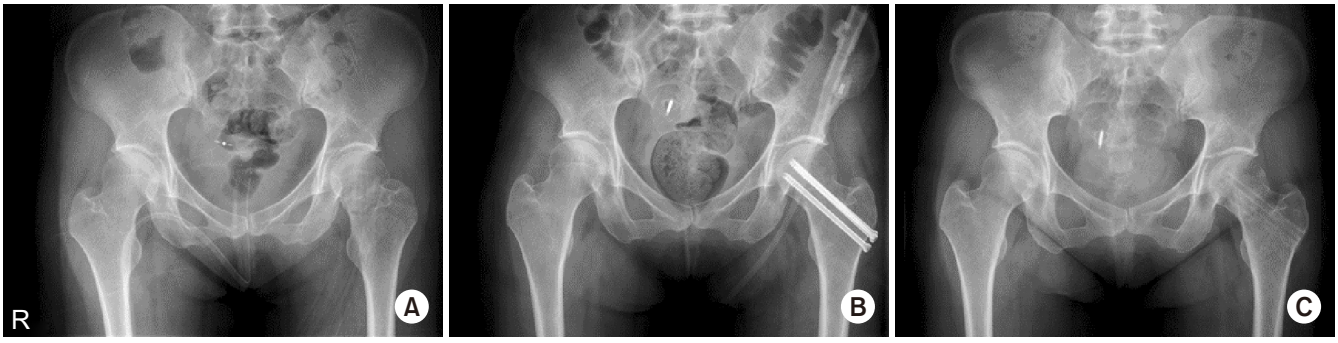

Fig. 1. A 62-year-old female demonstrated pain in the left hip and diagnosed as femur neck fracture. (A) Preoperative pelvis anteroposterior (AP) plain radiographs showing 38 degrees of initial Pauwels' angle. (B) Postoperative hip AP plain radiographs using cannulated screws showing good anatomical reduction quality. (C) Final follow up plain radiographs demonstrating well maintenance of reduction quality.

Discussion

Internal fixation is one of the conventional treatment of choice for undisplaced FNF in young and active patients.[14-16] On the contrary, in elderly patients with FNF, internal fixation has been reported higher rates of revisional surgery, complication, non-union, delayed union, and poorer functional outcomes.[17] Hence, some studies recommend the arthroplasty rather than internal fixation in elderly patients with FNF.[17] However, it is judged that internal fixation is still has several advantages in elderly patients. It enables shorter operation time, less blood loss and less incidence of deep wound infection.[17] Moreover, other studies have reported that age is not associated with mortality, rate of fixation failure, or the ultimate functional results.[18]

Some studies reported the factors which influence the

Table 2. Comparison of Radiographic Variables between the Fixation Failure and the Non-Failure Groups in Femoral Neck Fractures

Variable	Failure group (n=17)	Non-failure group (n=66)	p-value
Initial Pauwels' angle			
<30°	0 (0)	18 (27.3)	<0.001*
30°-50°	5 (29.4)	37 (56.1)	0.254
>50°	12 (70.6)	11 (16.7)	0.124
Fracture level			
Subcapital	13 (76.5)	53 (80.3)	0.245
Transcervical	2 (11.8)	9 (13.6)	0.112
Base of the neck	2 (11.8)	4 (6.1)	0.060
Reduction quality†			
Anatomical	8 (47.1)	59 (89.4)	<0.001*
Non-anatomical	9 (52.9)	7 (10.6)	0.060

Values are presented as number (%). *p<0.05. †Garden's angle.

Table 3. Comparison of Surgical Variables between the Failure and the Non-Failure Groups with Femoral Neck Fractures

Variable	Failure group (n=17)	Non-failure group (n=66)	p-value
Time to surgery			
<12 h	2 (11.8)	35 (53.0)	<0.001*
≥12 h	15 (88.2)	31 (47.0)	0.080
Surgical time (min)	62.9±20.8	59.2±17.6	0.101
Estimated blood loss (ml)	137.8±56.5	103.6±49.8	0.081

Values are presented as number (%) or mean±standard deviation. *p<0.05.

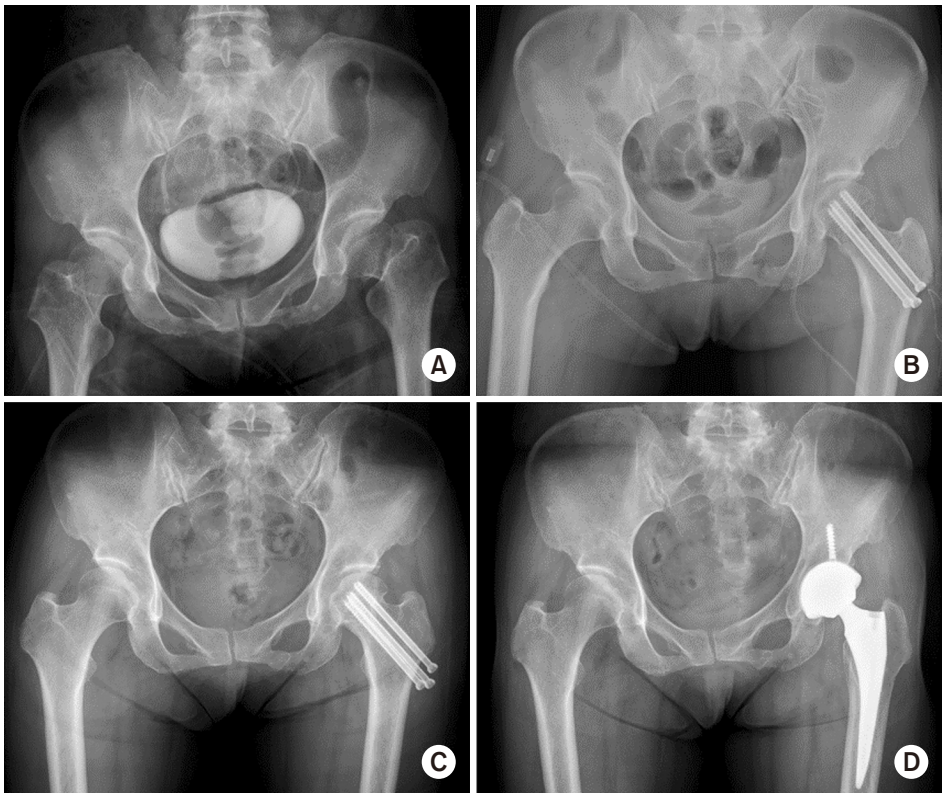

Fig. 2. A 65-year-old female demonstrated pain in the left hip and was diagnosed with a femoral neck fracture. (A) Plain radiographs of preoperative pelvis in anteroposterior (AP) view showing displaced fracture of the femoral neck. Due to the general condition of the patient, surgery was performed after 15 hours of the initial trauma. (B) Plain radiographs of postoperative hip in AP view showing osteosynthesis with cannulated screws. (C) Plain radiographs of hip in AP view at follow-up demonstrating varus hip due to the avascular necrosis of the femoral head and neck. (D) Plain radiographs at final follow-up demonstrating a state of total hip arthroplasty due to the internal fixation failure of the femur neck fracture.

outcomes after internal fixation in FNF.[18,19] Gregersen et al.[20] found that poor reduction quality of FNF which is defined as greater than 5 mm of fracture displacement, outrange the Garden angle AP plain radiograph which the interval of 160°–175°, or greater than 20° of AP angulation is associated with high risk of revision surgery. This finding was consistent with our study that poor reduction led to a higher risk of treatment failure following internal fixation of FNF. Chang et al.[21] reported the patient and surgical factors for outcomes of internal fixation of FNF. Though Chang et al.[21] mentioned that preoperative Pauwels' angle is not associated with the postoperative outcomes, in this study, lower preoperative Pauwels' angle group showed favorable outcomes compared to the higher one.

Previous studies reported that the failure rate as 28.0%–53.5% and the AVN rate as 10.0%–46.2% after internal fixation of displaced FNF, respectively.[7,14,16] Although in our study, the percentage of Garden type 1 and 2 were higher than that of Garden type 3 and 4, the overall failure rate was noted as 20.3% and the AVN rate as 9.6%, respectively. Jain et al.[22] reported that early reduction and fracture fixation within 12 hours of injury after a displaced FNF could reduce the incidence of AVN. On the contrary, Papakostidis et al.[23] argued that there were no significant differences in the AVN rate of the delayed internal fixation group. In the current study, the group in which internal fixation was performed within 12 hours after injury showed a failure rate of 5.4% and an AVN rate of 2.7%. In comparison, the group in which internal fixation was not performed within 12 hours showed a higher failure rate of 32.6% and an AVN rate of 15.2%. Hence, it is assumed that early fracture reduction reduces the rate of postoperative AVN, resulting in decreases the rate of fixation failure. Thus, performing surgery within 12 hours after injury could be a key factor for achieving successful results.

This study had several limitations. First, owing to the retrospective nature of the study, the factor of time was not precisely established. It would have been better to collect data from the onset of clinical symptoms to the time of surgery. Second, the number of cases was relatively small. A small sample size often leads to a type II error, but the adequacy of the present study was proven on the basis of the post hoc analysis results with a power of 80.7%. Third, in this study, we did not use a logistic regression analysis to find the risk factors for internal fixation failure in FNF. If a logistic regression analysis had been done, we could have been more accurately known the association between risk factors and internal fixation failure in FNF. Finally, we could not involve the bone mineral density data of patients due to the lack of osteoporosis evaluation. While Barrios et al.[24] argued that osteoporosis has no statistically significant difference in internal fixation failure between failure and non-failure group, Spangler et al.[25] stated that presence of osteoporosis could be the predictive factor of revision surgery in femur fracture patient. As many studies have argued different theory of osteoporosis as the factor associated with internal fixation failure, further data collection and assessment will be required in our next study.

Conclusion

Pauwels' angle, reduction quality and time to surgery are major factors that can predict the possibility of internal fixation failure of FNF. Hence, early and accurate anatomical reduction is needed to decrease complications after internal fixation of FNF.

요 약

목적: 대퇴 경부 골절이 발생한 환자에서 내고정술 시행 시 내고정 실패의 위험 요인에 대하여 분석하고자 한다.

대상 및 방법: 2002년 7월부터 2017년 3월까지 대퇴 경부 골절로 진단받은 후, 내고정술을 시행 받은 50세 이상 환자군을 대상으로 하였다. 1년 이상 추적 관찰이 가능한 환자들을 내고정 실패가 발생하지 않은 군과 실패가 발생한 군으로 분류하였다. 수술 전, 후의 방사선학적 검사 소견 및 수술까지 걸린 시간, 수술 소요 시간, 추정 출혈량과 같은 수술 중 변수에 대하여 분석하였다.

결과: 전체 83명의 환자군에서 총 17명(20.5%)에서 내고정 실패를 보였다. 영상학적으로 초기 전위 정도인 Pauwels 각도와 정복의 질을 나타내는 Garden 각도를 기준으로 두 군을 비교했을 시 통계적으로 유의하였고($p<0.001$; $p<0.001$), 수

술 중 변수를 비교하였을 시 손상 후 수술까지의 시간 간격, 특히 손상 후 12시간 이내 수술 여부에 유의한 차이가 있었다($p<0.001$).

결론: Pauwels 각도, 정복의 질, 수상 후 수술까지의 시간은 대퇴 경부 골절이 발생한 환자에서의 내고정술 실패 가능성을 예측할 수 있는 주요 인자이다. 따라서, 대퇴 경부 골절 환자에서 내고정술 시행 시 정확한 해부학적 정복과 이른 수술이 필요하다.

색인 단어: 대퇴 경부 골절, 내고정술, 내고정술 실패, Pauwels 각도, 수술까지 걸린 시간

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