석 사 학 위 논 문

High Fixation Failure of Cephalomedullary Nail Fixation with Basicervical Femur Fractures according to Reduction Status

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이 논문을 석사학위 논문으로 제출함

2023년 2월

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마지막으로 지금 이 자리에 있게 해주고 항상 응원해주시고 믿어준 가족에게 마음을 전하며 이 논문을 바칩니다.

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김 영 훈

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1. Introduction

Among proximal femur fractures, basicervical femur fracture is a relatively rare type of fracture. In general, it has been reported that basicervical femur fractures account for 1.8% to 7.6% of all proximal femur fractures (1,2). Various papers have described fractures of this type in different ways. For example, after the term basicervical, terms such as femur intertrochanteric fracture, neck fracture, and peritrochanteric fracture are combined and utilized (3-8). The difference in terminology may be due to the anatomical location of the basicervical area. The definition of basicervical fracture has not been clearly unified. The most commonly used definition is a proximal femoral fracture through the base of the femoral neck at its junction with the intertrochanteric region (3,4). A recent article reported that the fracture line is located at the base of the femoral neck and is medial to the intertrochanteric line and exits above the lesser trochanter but is more lateral than a classic transcervical fracture (9). The methods used for treatment of basicervical femur fractures are still under debate. According to published reports, a relatively high failure rate was reported for treatment of basicervical femur fractures with a sliding hip screw, and some studies reported good results for fixation with a cephalomedullary nail (10,11). Currently, cephalomedullary nails are preferred for the treatment of peritrochanteric femur fractures.

However, Watson et al. (12) reported a high failure rate in the treatment of basicervical fracture with a cephalomedullary nail, demonstrating that the choice of cephalomedullary nail was controversial for the treatment of basicervical fracture. Many studies have focused on surgical outcomes according to implant selection. Finding studies focusing on

differences in outcome of basicervical fracture according to objective reduction states is difficult. The purpose of this study was to analyze the outcome according to the reduction status of patients who underwent head cephalomedullary nail fixation for a basicervical femur fracture.

2. Materials and Methods

Institutional review board approval was obtained for retrospective study (No. 2020-03-039). From 2007 to 2018, radiographs of patients with proximal femur fractures were reviewed, and patients with basicervical fractures were included in the study. Analysis of 3-dimensional computed tomography (3D CT) images using simple radiographs was possible because this study had taken preoperative 3D CT images of patients with proximal femur fractures. In comparison of simple radiographs and CT images, even though it was judged as a pure 2-part basicervical fracture on a simple radiograph, many cases with minor fractures of a great trochanter were observed on CT (Figure 1). In consideration of this, not only patients with simple 2-part basicervical fractures, but also patients with basicervial fracture with a minimally displaced small fragment of the great trochanter were included in the study. Thus, 49 patients (50 Hips) were identified in the radiologic review.

Among them, three patients underwent osteosynthesis using a dynamic hip screw and seven patients underwent hip arthroplasty. Thirty-nine patients (40 Hips) underwent osteosynthesis using a cephalomedullary nail. Among them, 17 patients (18 Hips) died during follow-up or follow-up was lost. Finally, 22 patients (22 Hips) were selected for analysis of postoperative outcomes.

For evaluation of the reduction status after surgery using simple radiographs, three reduction types were classified in the antero-posterior AP) view and three reduction types in the lateral view. In the AP view, when the proximal fragment is on the medial side of the medial cortex of the distal fragment, it is known as the extramedullary type, the ana-

tomical type when it is in the anatomical position of the medial cortex, and the intramedullary type when it is on the lateral side of the medial cortex. In the lateral view, when the proximal fragment is on the anterior side of the anterior cortex of the distal fragment, it is known as the extramedullary type, when it is in the anatomical position of the anterior cortex, the anatomical type, and when it is on the posterior side of the anterior cortex, the intramedullary type (Figure 2). An analysis of the postoperative simple radiographs of 22 patients was performed. In AP view, 13 patients were extramedullary type, nine patients were anatomical type, and there were no patients with intramedullary type. In the lateral view, all 22 patients were classified as anatomical reduction type. In the lateral view, all patients had the same reduction status (anatomical reduction type), therefore, based on the AP view, 22 patients were divided into 13 patients of extramedullary reduction type into the extramedullary group, and nine patients of anatomical reduction type into the anatomical group.

Fixation failure was defined as a substantial collapse of the fracture site with sliding of the lag screw, resulting in a cut through or cut out of the lag screw, or rotation of the proximal fragment, or nonunion of the fracture (Figure 3).

The Mann-Whitney U test, Chi-square test, or Fisher's exact test was used for analysis of statistical data between the two study groups. p-values less than 0.05 were considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics (version 23.0; IBM Co., NY, USA).

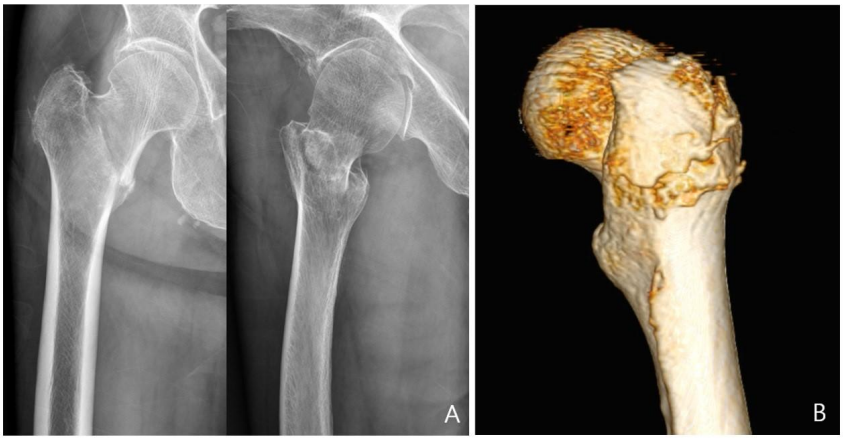

Figure 1. Simple radiograph of a basicervical femoral fracture patient. In the anterior-posterior view, the fracture is seen as a 2-part fracture, and in the lateral view, the fracture comminution of the great trochanter is not clearly visible (A). It can be confirmed that there is a minimally displaced fracture in the great trochanter through the 3-Dimensional CT image (B). CT: computed tomography.

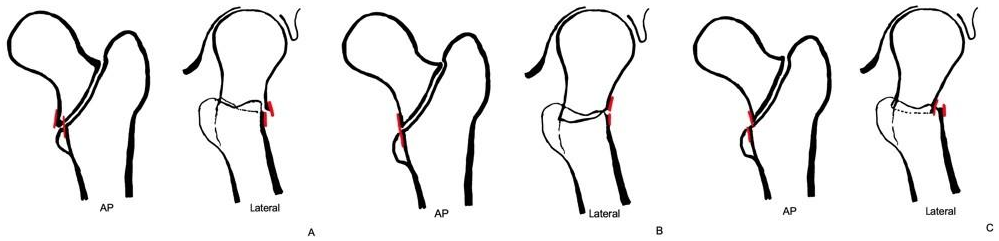

Figure 2. Illustration for classifying the reduction states in the AP and lateral view separately. Extramedullary reduction state (A). Anatomical reduction state (B). Intramedullary reduction state (C). AP: Anteroposterior.

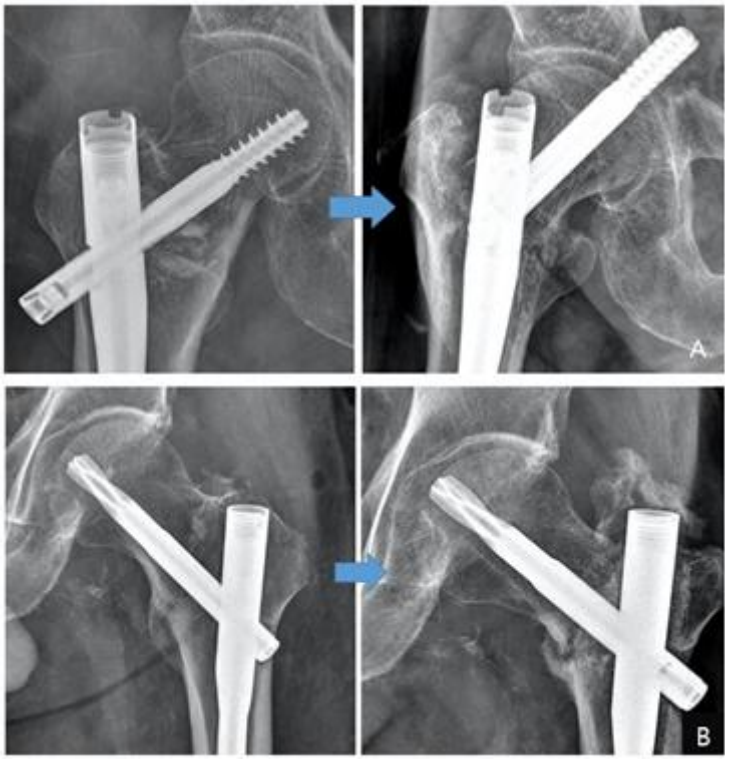

Figure 3. Two types of failure observed in basicervical fractures. Cut through or cut out of the lag screw (A). Rotational failure with non-union (B).

3. Results

Fixation failure occurred in four patients (18.1%). None of the patients in the extramedullary group had fixation failure (0%). Fixation failure occurred in four patients (44.4%) in the anatomical group. A statistically significant difference in the rate of fixation failure was observed between the two reduction groups ($p < 0.05$). Among these patients, the fixation failure modes were cut through (two cases) and rotational failure (two cases) (Table 1). Complications other than fixation failure occurred in two cases. In the anatomical group, one distal femur fracture occurred and osteosynthesis using a plate was performed. In the extramedullary group, development of avascular necrosis of the femoral head occurred in one patient, and arthroplasty conversion was performed. No statistically significant differences in age, body mass index (BMI), and follow-up period were observed between the two groups (Table 2).

Table 1. Data of Patients with Fixation Failure

Case	Age (year)	Sex	Study group (reduction)	Implant	Tip apex distance (mm)	Mode of failure	Intervention
1	89	F	Extramedullary	Gamma-3	19.2	Cut through	Hemiarthroplasty
2	86	F	Extramedullary	PFNA-II	12.1	Rotational failure	No intervention due to lower function
3	77	F	Extramedullary	Gamma-3	19.4	Cut through	Total hip arthroplasty
4	66	M	Extramedullary	PFNA-II	10.9	Rotational failure	Total hip arthroplasty

F: female; M: male; PFNA; froximal femur nail anti-rotation.

Table 2. Demographic Data

	Extramedullary group	Anatomical group	p-value
Number of patients	13	9	
Gender (male / female)	12 / 1	6 / 5	
Fixation implant (PFNA Ⅱ / Gamma-3)	11 / 2	6 / 3	
Age (years)	76.6 (70 - 85)	76.4 (52 - 83)	$p > 0.05$
Body mass index (kg / m^2)	21.0 (7.1 - 21.9)	23.1 (7.1 - 20.1)	$p > 0.05$
Length of follow-up (months)	28.7 (12 - 64)	30.6 (12 - 46)	$p < 0.05$*

*: Statistically significant ($p < 0.05$).

4. Discussion

A relatively high rate of fixation failure was observed in patients with basicervical femur fractures who underwent surgery using a cephalomedullary nail. Among them, all fixation failures occurred in the anatomical reduction group, and no fixation failure occurred in the extramedullary reduction group.

The average tip-apex distance (TAD) of the cases with fixation failure was 15.2 mm, and there was no significant difference from the average TAD of the other cases without fixation failure, meeting the acceptable TAD range. In analysis from the technical aspect of surgery, the reduction state can affect the outcome of the surgery, assuming that the implant position is appropriate.

Watson et al. (12) reported that the use of a cephalomedullary nail in a 2-part basicervial femur fracture was not appropriate due to the high rate of fixation failure. However, in that study, anatomical or nearly anatomical reduction was obtained in all cases. Although the criteria and classification of nearly anatomical reduction are not clear, a similarly high rate of fixation failure was observed in the anatomical reduction group in this study. Hu et al. (13) reported good results with the use of a cephalomedullary nail in treatment of basicervical femur fractures, however, compared with this study, there is a difference in that the average age of the study patients was relatively young and the patterns of basicervical femur fractures included in the study were more diverse. Su et al. (6) mentioned that collapse occurs more often with basicervical fractures compared with intertrochanteric fractures, suggesting that they may have greater biomechanical instability. Therefore, recent studies have concentrated on the study of the difference in the results according

to implant choice in basicervical femoral fractures. Kim et al. (14) reported better results with the blade type or two integrated screw type lag screw compared with the single screw type when a cephalomedullary nail was used in treatment of basicervical femur fractures. Sharma et al. (15) compared and reported the results of treatment using cancellous cannulated lag screws (CCS), dynamic hip screws (DHS) with a derotation screw, and proximal femoral nails (PFN). They reported that CCS does not provide sufficient stability, PFN is more stable, but has a higher frequency of technical errors, and DHS stated that it provides sufficient stability in a well-reduced state. Kwak et al. (16) conducted a biomechanical comparison of cephalomedullary nails using three types of lag screws (screw, screw blade hybrid, helical blade) in treatment of basicervical femoral fractures; the helical blade and screw blade hybrid types showed rotational instability. However, it was reported that there is a higher probability of migration of proximal fragments accompanied by varus collapse with the helical blade compared with the screw blade hybrid type. Xiong et al. (17) reported that the sliding hip blade connected with a side-plate is the best option for basicervical femoral fractures. Various studies have reported on surgical outcomes according to implant choice, however these studies commonly reported that the reduction status was anatomical or accepted reduction. It has been reported that Wayne-County reduction is better than anatomical reduction in unstable comminuted intertrochanteric femoral fractures (18,19). The shape of Wayne-County reduction on simple radiographs is similar to that of the basicervical femoral fractures classified as the extramedullary reduction group in this study. Because basicervical femur fractures are more unstable than intertrochanteric femur fractures, a high probability of failure, such as unstable intertrochanteric fractures, must be recognized and considered (6,20,21). In the case of extramedullary reduction, it

is thought that the proximal bone fragment could have stability with the support of the anteromedial calcar area, and this would have lowered the possibility of fixation failure.

The limitation of this study is its small number of cases and the retrospective design of study. In addition, two implants were used without using a single implant, and the number of cases was not sufficient for analysis of the difference in the surgical results for each implant. Because there was no case of intramedullary reduction in this study, analysis of the surgical results of the intramedullary reduction group was not possible, and further study analysis is required by expanding the study subject in the future. Not only pure 2-part basicervical fractures but also basicervical fractures with small, minimally displaced fragments of the great trochanter were included in the study, which may make objective comparison of the results of other studies difficult.

However, in this study, 3D CT scans were performed in all patients for analysis of the preoperative fracture pattern, and many cases showed minimal displacement of the great trochanter fragment as a result of the actual CT analysis of the cases that appeared to be simple 2-part fractures on simple radiographs. Considering these cases, they were included in the study subjects. In addition, the classification method that can be used for objective evaluation of the postoperative reduction state is presented; this is the difference between this study and other studies.

5. Summary

The purpose of this study is to analyze outcome according to the reduction status of patients who underwent cephalomedullary nail fixation for treatment of a basicervical femur fracture, twenty two patients with basicervical femur fracture were selected for analysis of postoperative outcomes. For evaluation of reduction status after surgery using simple radiographs, three reduction types were classified in the AP and lateral view. In the treatment of low energy basal cervical femoral fractures, a high rate of fixation failure was observed in the anatomical reduction group when a cephalomedullary nail was used. On the other hand, no fixation failure was observed in the extramedullary reduction group. This result provides a clue as to what kind of reduction status should be obtained to achieve good results in treatment of a special fracture known as a basicervical femur fracture. The definition of the basicervical femur fracture is unclear, so it is needed that more clear consensus about definition of the basicervical peritrchanteric femur fractures. And further studies with long-term and comparative evaluation will be needed for these high-risk patients.

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High Fixation Failure of Cephalomedullary Nail Fixation with Basicervical Femur Fractures according to Reduction Status

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(Abstract)

The purpose of study is to analyze the outcome according to the reduction states of patients who underwent cephalomedullary nail fixation for treatment of a basicervical femur fracture. Twenty-two patients with basicervical femur fracture were selected for analysis of postoperative outcomes. For evaluation of the reduction states after surgery using simple radiographs, three reduction types were classified in the antero-posterior (AP) and lateral view. An analysis of the postoperative simple radiographs of 22 patients was performed. In the lateral view, all patients had the same reduction status (anatomical reduction), based on the AP view, 22 patients were divided into 13 patients of extramedullary reduction into the extramedullary group, and 9 patients of anatomical re-

duction into the anatomical group. Fixation failure occurred in four patients (18.1%) In the extramedullary group, none of the patients (0%) had fixation failure. In the anatomical group, fixation failure occurred in four patients (44.4%). A statistically significant difference in the rate of fixation failure was observed between the two reduction groups ($p < 0.05$). In the treatment of basicervical femur fractures, a high rate of fixation failure was observed in the anatomical group and no fixation failure was observed in the extramedullary group.

Cephalomedullary nail을 이용한 저에너지 손상으로 인한 대퇴하경부 골절 치료에서 정복상태에 따른 높은 실패율

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(초록)

이 연구의 목적은 대퇴하경부 골절에서 cephalomedullary nail을 이용한 환자에서 정복상태에 따른 결과를 연구하는 데 있다. 대퇴하경부 골절로 치료받은 22예의 환자들을 후향적으로 조사하였다. 술 후 단순 방사선 사진을 이용한 평가를 위해, 골수강 내, 골수강 외, 해부학적의 3가지 정복으로 분류하였다. 22예의 술 후 단순 방사선 사진을 분석하였다. 측면 방사선 사진에서 모든 예에서 해부학적 정복상태를 얻었고, 전후면 방사선 사진에서 13예에서 골수강 외 정복을 얻어 골수강 외 정복군으로 분류하였고, 9예에서 해부학적 정복을 얻어 해부학적 정복군으로 분류하였다. 고정 실패는 4예에서 발생하였다 (18.1%). 골수강 외 정복군에서는 고정 실패가 없었으며 (0%), 해부학적 정복군에서 4예의 고정 실패가 발생하였다 (44.4%). 두 정복군 간의 고정 실패에서 유의한 차이를 보였다 ($p < 0.05$). 저에너지 손상으로 인한 대퇴하경부 골절의 치료에서, 해부학적 정복군에서 높은 실패율

을 보였으며 골수강 외 정복군에서는 고정 실패는 보이지 않았다.