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Original Article

Single screw type of lag screw results higher reoperation rate in the osteosynthesis of basicervical hip fracture

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ABSTRACT

Background: Basicervical hip fractures are relatively rare with greater biomechanical instability compared to the other types of hip fractures. Several studies have reported ambivalent surgical outcomes of basicervical hip fractures. The purpose of this multicenter study was to analyze surgical outcomes of basicervical hip fractures according to the fixation type of proximal femur and lag screw type.
Methods: Among 3220 hip fractures, 145 were classified as basicervical hip fractures. Of those, 106 patients treated with osteosynthesis were included to analyze the surgical complications according to fixation type of proximal femur: sliding hip screw(SHS) and cephalomedullary nail (CMN) groups. Surgical complications including the excessive displacement of fracture and the occurrence of reoperation were evaluated at the final follow up. We further evaluated surgical complications according to lag screw type with subgroup analysis in CMN group: single screw type, blade type and two integrated screw type.
Results: Ten patients (9.4%) sustained surgical complications (5 excessive displacements and 5 reoperations). For fixation type of proximal femur, SHS group showed higher tendency of excessive displacement despite no statistical difference between the two groups ($p = 0.060$). For lag screw type with subgroup analysis in CMN group, single screw type showed statistically high rates of reoperation compared to the other types of lag screw ($p = 0.022$).
Conclusion: Basicervical hip fractures treated with osteosynthesis resulted to high rates of surgical complications in this study. However, they could be drastically reduced if CMN with blade type or two integrated screw type were used in the osteosynthesis of basicervical hip fractures.

1. Introduction

Hip fractures are common in elderly patients. They are consistently increasing with longer life expectancy [1,2]. There are two types of hip fractures [3]: 1) intracapsular type which is usually treated with multiple pinning or arthroplasty; and 2) extracapsular type which is usually treated with sliding hip screw or cephalomedullary nail. However, basicervical fracture is located at the border of intracapsular and extracapsular fracture. It is defined as a proximal femoral fracture through the base of femoral neck at its junction with the intertrochanteric region [4]. Due to this location, it represents an intermediate form between intracapsular and extracapsular fractures [5,6].

Basicervical hip fractures are relatively rare compared to other types of hip fractures. It has been reported that 1.8%–7.7% of hip fractures are true basicervical fractures [5,7]. These basicervical fractures have greater biomechanical instability than other types of hip fractures [8].

Several studies have reported ambivalent surgical outcomes of basicervical fractures. Earlier study has reported that sliding hip screw (SHS) is obviously unstable in rotatory stresses due to conical shape and an additional cancellous screw is probably needed to solve this problem in basicervical hip fractures [9]. However, another study has reported that using additional screw with SHS does not affect fracture stability or clinical outcome [8]. A later study has reported that surgical treatment of basicervical hip

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fractures with cephalomeduallary nail (CMN) is very effective [10]. But, a recent study has shown that CMN may be inadequate for fixation of basicervical fractures [11].

Previous studies on basicervical hip fractures are usually case series which could not evaluate the critical factors to affect their surgical outcomes [12]. The objective of this multicenter study was to analyze the surgical outcome of basicervical hip fractures according to fixation type of proximal femur and subgroup analysis of CMN group according to lag screw type.

2. Materials and methods

Between 2011 and 2014, 3220 patients aged 60 years or older with hip fractures were treated at five tertiary hospitals. Each of these hospitals treated more than 150 patients with hip fractures per year. Five orthopedic surgeons representing these hospitals are specialized in treatment of hip fractures and related diseases. The research protocol was approved by our Institutional Review Board and informed consent was waived for this study.

Patients were included in our study if radiographs showed basicervical hip fracture of the proximal part of the femur defined as a two-part fracture at the base of the femoral neck that was medial to the intertrochanteric line, exiting above the lesser trochanter but was more lateral than a classic transcervical fracture [11]. Fractures in which the lesser trochanter was a separate fragment or the fracture line exited distal to the lesser trochanter or out the lateral cortex of the greater trochanter were excluded. All preoperative radiographs were re-evaluated to ensure that there was no evidence to reclassify these fracture patterns as either transcervical or intertrochanteric. Among these patients, those who underwent hip arthroplasty for the treatment of basicervical hip fractures were excluded. This retrospective study was approved by our Institutional Review Board. Demographic data included age, sex, body mass index (BMI), and American society of anesthesiologists (ASA) score preoperatively. Operative data included type of anesthesia, operative time, estimated blood loss, tip-apex distance (TAD), lag screw position, and fracture reduction state during operation. TAD was measured on postoperative radiograph as defined by Baumgaertner et al. [13]. Lag screw position was classified as good, acceptable, or poor according to Gardenbroek et al. [14]. Fracture reduction state was assessed with the criteria proposed by Fogagnolo et al. [15].

Among them, patients who were lost to follow-up or died less than one year after surgery (15 patients) were excluded from final evaluation of basicervical hip fractures.

First, we analyzed surgical complications according to the fixation type of proximal femur: SHS or CMN group. Second, we evaluated surgical complications according to the lag screw type with subgroup analysis in CMN group: single screw type, blade type and two integrated screw type. Surgical complications including the excessive displacement of the fracture by femoral medialization of >30% [16] and the occurrence of reoperation were evaluated at the final follow up.

2.1. Statistical analysis

All continuous data are expressed as means and standard deviations. For statistical analysis, Student's *t*-test and Analysis of variance (ANOVA) was used for continuous data while Pearson's Chi-squared test and Fisher's exact test was used for categorical data. All statistical analyses were conducted using SPSS v15.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was considered at $p < 0.05$.

3. Results

Of 3220 hip fractures, 145 (4.5%) were classified as basicervical hip fractures. Twenty-four patients with basicervical hip fractures who underwent hip arthroplasty were excluded from this study. Among the remaining 121 patients with basicervical hip fractures treated with osteosynethsis, 15 died or lost to follow up less than one year after the surgery. The remaining 106 patients with basicervical hip fractures were finally included in this study. Mean follow up period were 2.2 (1.0–3.6) years.

Ten patients (9.4%) sustained the surgical complications at the final follow up (Table 1). Five patients sustained excessive displacement without reoperation. Five patients sustained reoperation due to cut-out of lag screw, osteonecrosis of femoral head or postoperative femoral neck fractures.

First, we analyzed the surgical outcomes according to the fixation type of proximal femur: SHS or CMN group. Thirty nine patients were included in the SHS group and 67 patients were included in the CMN group (Table 2). Their demographic or operative data showed no statistically significant difference except operative time ($p = 0.003$). SHS group showed higher tendency of excessive displacement despite no statistical difference between the two groups ($p = 0.060$). There was also no statistically difference in the occurrence of reoperation ($p = 0.650$).

Second, we evaluated surgical complications according to the lag screw type with subgroup analysis in CMN group: single screw type, blade type and two integrated screw type (Table 3). Three cases of Gamma-3 nail (Stryker, Kiel, Germany), 11 cases of Zimmer natural nail (ZNN) (Zimmer, Warsaw, USA), and 10 cases of ITST nail (Zimmer, Warsaw, USA) were included in the single screw type. Twenty five cases of Proximal Femoral Nail Antirotation (PFNA) nail (DePuy Synthes, Solothurn, Switzerland) and 18 cases of InterTAN nail (Smith-Nephew, Memphis, TN) were included in the blade type and two integrated screw type, respectively.

Table 1
Data of ten patients sustained the surgical complications after the osteosynthesis of basicervical hip fractures.

Cases No.	Age (years)	Sex	Implant	Fixation of proximal femur	Lag screw type	Lag screw position	TAD (mm)	Fracture reduction status	Surgical complications	Cause of revision	Time to revision (months)
1	77	F	DHS	SHS	SC	Good	19	Good	ED		
2	81	F	DHS	SHS	SC	Good	15	Acceptable	ED		
3	75	F	DHS	SHS	SC	Good	18	Good	Revision	ONFH	39.9
4	82	M	DHS	SHS	SC	Good	22	Good	ED		
5	85	F	DHS	SHS	SC	Good	11	Good	ED		
6	70	F	ITST	CMN	SC	Good	23	Acceptable	Revision	cutout	2.7
7	77	F	ZNN	CMN	SC	Good	21	Good	Revision	cutout	6.5
8	78	F	ZNN	CMN	SC	Good	22	Good	Revision	cutout	3.3
9	78	F	ZNN	CMN	SC	Good	23	Good	Revision	FNF	13.6
10	71	F	PFNA	CMN	Blade type	Good	23	Good	ED & ONFH		

TAD: Tip apex distance, SHS: Sliding hip screw, CMN: Cephalomedullary nail, SC: Single circular type, ED: Excessive displacement.
ONFH: Osteonecrosis of femoral head, FNF: femoral neck fracture.

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Table 2
Comparison according to the fixation type of proximal femur in the patients with basicervical hip fractures. Continuous variables were described as mean (SD).

	SHS (n = 39)	CMN (n = 67)	*P-value*
Demographic data			
Age (years)	76.4 (7.9)	77.5 (8.3)	0.486
Sex (Male/Female)	16/23	23/44	0.490
BMI(Kg/m^2)	21.4 (3.2)	22.0 (3.8)	0.410
ASA score	2.5 (0.6)	2.6 (0.6)	0.293
Operative data			
Anesthesia			0.192
General	13	31	
Spinal	26	36	
Op time (minutes)	86.2 (44.1)	63.9 (31.0)	***0.003**
Estimated blood loss (ml)	407.9 (329.9)	331.1 (222.1)	0.196
TAD (mm)	18.0 (5.7)	16.3 (6.1)	0.174
Lag screw position			1.000
Good	37	62	
Acceptable	2	5	
Reduction state			1.000
Good	38	65	
Acceptable	1	2	
Hospital stay (days)	26.9 (22.0)	24.1 (11.9)	0.470
Surgical Complications			
Excessive displacement	4	1	0.060
Reoperation	1	4	0.650

SHS: Sliding hip screw, CMN: Cephalomedullary nail, BMI: Body mass Index, ASA score: American Society of Anesthesiologists score, TAD: Tip-apex distance.
*P-value < 0.05.

Demographic or operative data showed no statistically significant difference between the two groups except body mass index (BMI) ($p = 0.015$). Single screw type showed statistically high occurrence of reoperation ($p = 0.022$) compared with other types of lag screw.

4. Discussion

Basicervical hip fractures are relatively rare but, reported the high failure rates after the treatment with osteosynthesis [17]. They might have greater biomechanical instability. Previous studies on basicervical hip fractures are usually case series which reported ambivalent results for treatments of basicervical hip fractures [8–11]. Our study showed that the failure rates could be drastically reduced if CMN with blade type or two integrated screw type were used in the osteosynthesis of basicervical hip fractures.

Basicervical hip fracture is a fracture located in the border of intracapsular and extracapsular fracture. It has been defined variably in previous studies [10,11,18,19]. With variability and ambiguity in its definition, prevalence of basicervical hip fracture varies from 1.8% to 7.6% [5,7,11]. The present study applied the recent definition of basicervical hip fractures (two-part fracture at the base of the femoral neck that was medial to the intertrochanteric line and exited above the lesser trochanter but was more lateral than a classic transcervical fracture) [11]. Our results showed that the prevalence of basicervical hip fracture was 4.5%, falling in range of its prevalence reported in previous studies.

The present study evaluated the surgical outcome of basicervical hip fractures treated with osteosynthesis. As the location of fracture site is at the border between extracapsular and intracapsular area, both extracapsular and intracapsular fracture treatments could be attempted. Since biomechanical and clinical studies have revealed better stability and clinical outcome when it is treated as an extracapsular fracture [4–6,8,17], it would be more important to evaluate the surgical outcome of basicervical hip fractures treated as extracapsular fractures.

Basicervical fracture has been regarded as mechanically unstable based on mechanical and observational study [11]. Blair et al. have stated that the lateral position of the fracture line minimizes the support of fixation devices from the lateral cortex [4]. Compared to intertrochanteric fracture, basicervical fracture has more collapse and failure than intertrochanteric fracture, meaning its more unstable character [8]. As the inherent fracture instability of basicervical hip fracture could lead to poor surgical outcomes [17], case-series with variable fixation devices have been attempted to suggest better options in the treatment of basicervical hip fractures. However, results are ambivalent. Kuokkanen et al. have reported that SHS is obviously unstable in rotatory stresses due to

Table 3
Subgroup analysis according to the lag screw type of cephalomedullary nail in the patients with basicervical hip fractures. Continuous variables were described as mean (SD).

	Single screw type (n = 24)	Blade type (n = 25)	Two integrated screw type (n = 18)	*P-value*
Demographic data				
Age (years)	78.7 (7.8)	77.0 (9.7)	76.9 (7.3)	0.729
Sex (Male/Female)	8/16	6/19	9/9	0.207
BMI(Kg/m^2)	21.9 (3.2)	23.4 (3.8)	20.1 (3.8)	***0.015**
ASA score	2.5 (0.7)	2.7 (0.6)	2.7 (0.5)	0.499
Operative data				
Anesthesia				0.556
General	9	13	9	
Spinal	15	12	9	
Op time (minutes)	58.7 (29.1)	66.8 (38.0)	66.9 (22.4)	0.592
Estimated blood loss (ml)	282.2 (263.2)	362.5 (185.6)	345.9 (218.6)	0.519
TAD (mm)	16.8 (6.3)	15.5 (5.0)	16.8 (7.3)	0.692
Lag screw position				0.936
Good	22	23	17	
Acceptable	2	2	1	
Reduction state				0.523
Good	23	25	17	
Acceptable	1	0	1	
Hospital stay (days)	21.8 (9.9)	26.4 (12.1)	24.1 (11.9)	0.413
Surgical Complications				
Excessive displacement	0	1	0	0.426
Reoperation	4	0	0	***0.022**

BMI: Body mass Index, ASA score: American Society of Anesthesiologists score, TAD: Tip-apex distance.
*P-value < 0.05.

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conical shape, thus needing an additional cancellous screw to solve this problem in basicervical hip fractures [9]. However, Su et al. have reported that using an additional screw with SHS does not affect fracture stability or clinical outcome [8]. Hu et al. have reported that CMN is very effective in the treatment of basicervical hip fractures [10]. However, a recent study by Watson et al. has shown that CMN may be inadequate for fixation of two-part basicervical hip fractures [11].

In the present study, SHS group showed higher tendency of excessive displacement despite no statistical difference between the two groups ($p = 0.060$) and single screw type in CMN group showed higher rates of reoperation compared to the other types of lag screw ($p = 0.022$). Controlled collapse in treating extracapsular fracture allows movement along with neck axis for axial compression at the fracture site while limiting torsional rotation and coronal angulation [20]. The complex and whirling patterns of cutout trajectory in the study of Bojan et al. indicated that the loading force at the proximal fragment is not simply an axial force [17]. Based on careful inspection on radiographs of six failed cases with CMN, Watson et al. have proposed that the asymmetric buttress against collapsing head-neck segment is the one that leads to rotational and angular failure [11].

PFNA was developed to improve rotational and angular stability with blade type lag screw. The PFNA blade can compact the cancellous bone and provide increased stability. It has been biomechanically proven to be able to retard rotation and varus collapse [21–23]. InterTAN nail was recently introduced and designed with two integrated lag screws to overcome Z-effect complications. It provides immediate intraoperative linear compression and rotational stability. Recent biomechanical studies has revealed that the devices with two integrated lag screws have better biomechanical properties [24–26].

We examined the fracture reduction quality as well as lag screw position which could affect the surgical outcome of hip fractures as a confounding bias in our study. Comparison of these factors between SHS and CMN groups as well as subgroup analysis in CMN group with three type of lag screw were similar, suggested that they would not influence the results of analysis in our study.

We acknowledge that this study has some limitations. First, our study was designed retrospectively. The rarity of basicervical hip fracture limited the design of this study. Second, various fixation devices were used in this study. However, we would properly categorize these fixation devices based on the literatures to find out critical factors affecting the surgical outcome of basicervical hip fractures [27]. Third, this multicenter study was performed by several surgeons in different hospitals. Different surgical experiences and hospital conditions would be concern. However, these five surgeons were trained at one hospital and lag screw position was checked in all cases.

5. Conclusions

Basicervical hip fractures treated with osteosynthesis resulted to high rates of surgical complications in this study. However, they could be drastically reduced if CMN with blade type or two integrated screw type were used in the osteosynthesis of basicervical hip fractures.

Conflicts of interest

None.

The design of the study

Retrospective multicenter study.

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