[J Tokyo Wom Med Univ
75 (10・11) 411〜423 (2005)]

Use of Compression Hip Screws in Trochanteric Fracture in the Elderly : Some Effects of Plate Angle on Clinical Results

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(Accepted September 10, 2005)

The purpose of this study is to compare the clinical results of the use of low-angle compression hip screws (135° CHSs) and high-angle compression hip screws (150° CHSs) for the surgical treatment of trochanteric fractures. The subjects were 130 patients 60 years of age or older who underwent CHS implantation (135° CHSs: 83 subjects; 150° CHSs: 47 subjects). Evaluation was performed based on radiographic findings and intraoperative variables. To compare these evaluation items between the two CHS groups, statistical analyses were performed; Multivariate analysis (MA) was used to eliminate confounding bias. Significant differences are found for four variables: ① operative time, ② quality of fracture reduction, ③ insertion position of screw into femoral head, and ④ healing time. Among these variables, operative time and healing time were affected by the differences in screw-plate angle. The use of 150° CHSs lengthened operative time and shortened healing time. There were no significant differences seen in extent of sliding and incidence of problematic deformity for which significant differences were expected on a theoretical basis based on the results of previous studies, and these two variables were not affected by differences in screw-plate angle.

Key words: compression hip screw, screw-plate angle, trochanteric fracture, sliding effect, clinical result

Introduction

Trochanteric fracture in elderly patients greatly reduces their ambulatory ability rendering a significant social problem of bedridden elderly people. Therefore, it is important for elderly patients who sustain trochanteric fractures to receive surgical treatment of fracture reduction and stabilization at an early stage and achieve early ambulation and rehabilitation in order for them to recover their ambulatory ability to preinjury level as quickly as possible.

The use of compression hip screws (CHSs) is a common fixation technique used for trochanteric fractures. CHSs are designed to allow a lag screw inserted into the femoral neck and head to slide within a tube plate fixed in the femoral shaft, producing continuous compressive force and stability at the fracture site, allowing early ambulation and rehabilitation. Numerous reports have been published on the various factors that affect the functional prognosis of patients receiving CHS implantation[1)~3)].

Reported systemic factors include age, sex, presence or absence of complications, ambulatory ability, and home environment. While local factors at preoperative time, include stability of the fracture site (Evans classification) and degree of osteoporosis. Those at immediate postoperative time, include quality of fracture reduction, screw position, and distance of lag screw insert, and at postoperative time, include extent of sliding and healing time and another important factor is postoperative therapy.

The question to answer here is whether differences in the screw-plate angle of the CHS used for fracture fixation serve as a factor influencing the functional prognosis of patients. It has been suggested that high angle (150°) is more likely to slide physiologically and easier to produce continuous compressive force than low angle (135°) due to their dynamics[4)~6)]. Hence, we compared postoperative outcome of surgeries performed using 135° and 150° CHS insertion angles.

Subjects and Methods

1. Subjects

Between June 1995 and April 2000, 175 patients with trochanteric fracture have been treated with CHSs at our department. For the purposes of the present study, patients younger than 60 years, patients who received other additional stabilization materials, patients who changed insertion angles since the previously planned angles did not fit, and patients who underwent open reduction surgery were excluded from this study. The remaining 130 patients were evaluated.

These subjects did not include patients who had pathological fractures or other trauma affecting ambulatory ability or patients with fractures classified as type II in the Evans classification, i.e., the fracture line extended to lateral cortical bone distal to the trochanter major or patients with ambi-lateral fracture. The subjects included 92 women and 38 men with ages ranging from 60 to 97 years and a mean age of 80.8 years. A screw-plate angle of 135° was used for 83 patients and 150° for 47 patients.

2. Treatment methods

1) CHSs

The CHSs used were the Compression Hip Screw 2400 Series ECT Type (Zimmer, Switzerland). The tube plate angles used were 135° (low angle) and 150° (high angle). Two or three-hole plates were used.

2) Operative method

The operation was performed with the patient immobilized in a supine position on a fracture table. A C-arm image intensifier was used to perform fracture reduction as accurately as possible. The incision was made as a standard lateral surgical exposure using standard CHS surgery techniques. A surgeon inserted a guide wire while watching enhanced views on the image intensifier, as centrally as possible or slightly medially to the femoral head in anteroposterior view and as centrally as possible to the head in lateral view. All surgeries were performed in the presence of at least two orthopedists; the author was present at all surgeries as either the surgeon or the first assistant surgeon. The numbers of surgeons present at the surgery was five and the author performed 63 cases (75.9%) for 135° CHS and 37 cases (78.9%) for 150° CHS.

3) Postoperative therapy

Prophylactic antibiotic administration was administered at the beginning of surgery. Heparin was administered to some patients with cardiac disease based on the instructions of their physicians. Postoperative therapy and rehabilitation were provided to all subjects in a similar manner. Starting with a sitting position or in a wheelchair, general active exercise designed not to affect the hip joint on the affected side was initiated on the day after surgery. Walking with the aid of a walker or crutches and straight leg raising exercise were initiated one week after surgery.

In anticipation that non-weight bearing ambulation of the affected leg might be difficult for patients in the targeted age group, weight-bearing was permitted when moving between bed, wheelchair and toilet only from the beginning of wheelchair use. Active and constant weight-bearing was initiated after bone union was confirmed. The abovementioned rehabilitation training was planned in consideration of patients' habitation circumstances after hospital discharge.

The initial goal was recovery of ambulatory ability to preinjury level and the subsequent goals were for patients to regain the abilities to walk and/or to perform activities of daily living (ADL) independently at discharge. As each patient's time to discharge drew nearer, potential problems were assessed by trial stays and possible solutions were evaluated. Once no further increase in the effects of rehabilitation exercises was seen, inpatient training was discontinued and patients were instructed to continue exercises on their own after discharge. No subjects exhibited marked changes in ambulatory ability and gait ability at periodic hospital visits following discharge.

Table 1 ASA score: anesthesia risk

Class 1	Normally healthy patient
2	Patient with mild systemic disease
3	Patient with severe systemic disease that is not incapacitating
4	Patient with an incapacitating systemic disease that is a constant threat to life
5	Moribund patient who is not expected to survive for 24 hr with or without operation

ASA: American Society of Anesthesiologist.

3. Evaluation variables (preoperative)

1) Sex

2) Age

3) Cause of injury

4) Number of days from injury to operation and number of days from hospitalization to operation

5) Complications on admission (existing before hospitalization)

6) ASA (American Society of Anesthesiologists) score[7] (Table 1)

ASA score was used to assess any health abnormalities present on admission. Subjects were classified and scored as shown in Table 1.

7) Fracture type

The Evans classification[8] was used to classify subjects' trochanteric fractures.

8) Bone density (Singh index)[9]

Bone density was assessed using preoperative radiographs of the subjects' hip of the healthy side. The state of trabecular bone in the proximal femur was assessed using the Singh index. Singh grades 1, 2, and 3 were considered to be an indication of the presence of osteoporosis, grade 4 was considered borderline, and grades 5 and 6 were considered to be an indication of the absence of osteoporosis.

4. Evaluation variables (intraoperative)

1) Anesthesia

Surgery was performed under either general or spinal anesthesia based on the decision of the anesthesiologist.

2) Operative time

Operative time was defined as the time required from skin incision to wound closure.

3) Blood loss

Blood loss refers to intraoperative blood loss.

5. Evaluation variables (postoperative)

1) Duration of stay in orthopedic ward, duration of hospital stay, and postoperative follow-up period

The term "duration of stay in orthopedic ward" is used if a patient is admitted and stayed only in orthopedic ward until discharge while the term "duration of hospital stay" is used if a patient is admitted to orthopedic department and received treatments at other departments after the surgery. During the postoperative follow-up period, 7 cases of death and 8 cases of those who changed the hospital in less than 3 months were excluded from the data. Ambulatory ability was assessed at the time of discharge as the patients who undergo trochanteric fracture surgery tend to stop visiting the hospital shortly after discharge.

2) Quality of fracture reduction

The quality of fracture reduction was evaluated using the methods of Gundle[10], Larsson[11], Obata[2], Thomas[12] and others based on radiographic images of the anteroposterior view of the hip and the lateral view of the femur taken immediately after surgery. The quality of fracture reduction was classified into anatomical reduction (anatomical form and continuation of medial cortex in anteroposterior view and anterior cortex in lateral view regained) and nonanatomical reduction (neither anatomical form nor bidirectional continuation of cortex regained).

Nonanatomical reduction was further classified based on the anteroposterior view into anteroposterior reduction, varus (10° or more varus from anatomical collodiaphyseal angle), valgus (10° or more valgus from anatomical collodiaphyseal angle) and anteroposterior displacement (4 mm or more displacement of continuation of medial cortex from anatomical position), and based on the lateral view into lateral reduction, flexion (10° or more flexion from than anatomical neck axis), extension (10° or more extension), and lateral displacement (4 mm or more displacement of continuation of anterior cortex from anatomical position). The combination of anteroposterior reduction and lateral reduction is classified into anatomical reduction.

3) Screw position (Fig. 1)

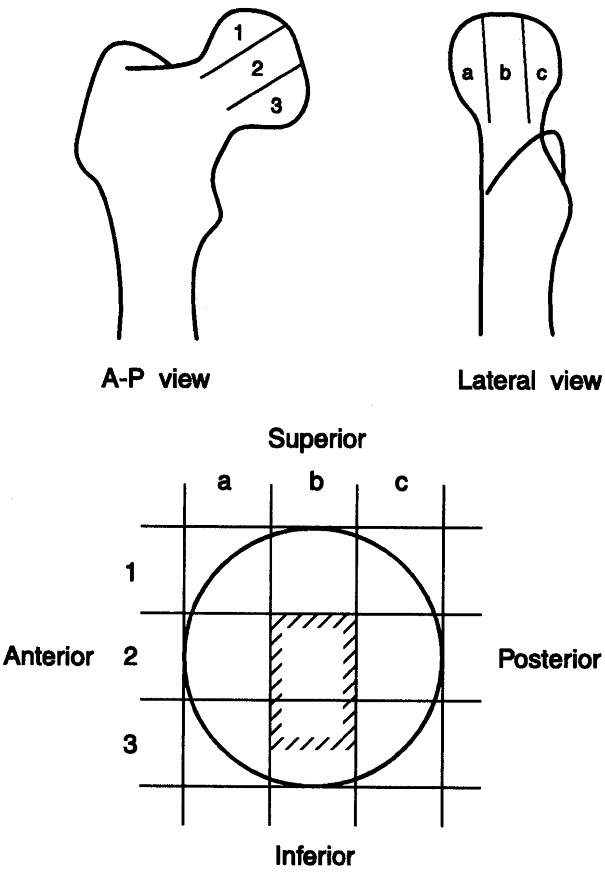

Fig. 1 Screw position
The adequate position is the shaded position

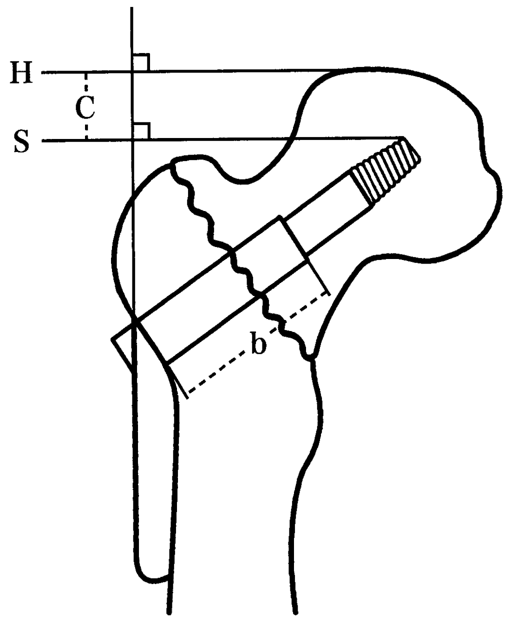

Fig. 2 Method to measure screw tip-subchondral bone distance (distance of lag screw insert)
H: subchondral bone of the femoral head, S: tip of screw, b: length of tube plate on radiograph, c: distance from tip of screw to subchondral bone on radiograph, k: constant length of tube plate as standardized article.
Corrected screw tip-subchondral bone distance
$= (c/b)k$

The insertion site of the lag screw in the femoral head was determined based on radiographs taken from two directional views immediately after the operation using the methods of Gundle[10], Thomas[12], and others. The femoral head was divided into three parts on the anteroposterior radiograph (superior, center, and inferior) and on the lateral radiograph (anterior, center, and posterior). Insertion sites thought to be adequate generally appear central or slightly inferior on the anteroposterior radiograph and central on the lateral radiograph.

4) Distance of lag screw insert (Fig. 2)

Screw tip-subchondral bone distance was measured on an anteroposterior radiograph taken immediately after the operation using the method of Doppelt[13]. The distance between the tip of the lag screw and the subchondral bone was measured between imaginary lines drawn perpendicularly to the side plate and passing through the screw tip and subchondral bone. The values obtained were

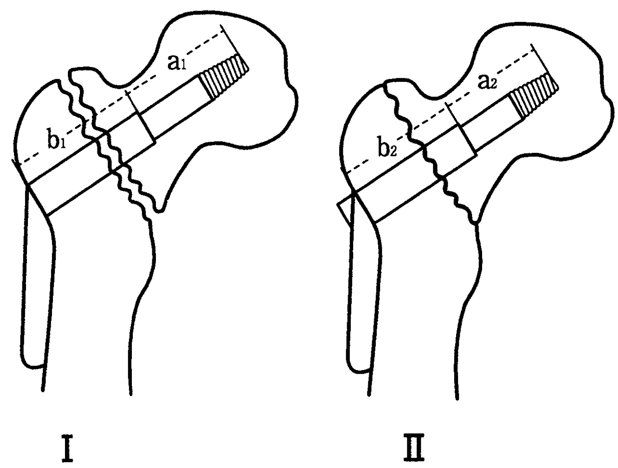

Fig. 3 Method to measure the extent of sliding
I: immediate postoperative radiograph, II: developmental radiograph
a: length of lag screw on radiograph (a_1: immediate postoperative, a_2: developmental)
b: length of tube-plate on radiograph (b_1: immediate postoperative, b_2: developmental)
k: constant length of tube-plate as standardized article
Corrected length of lag screw = $(a/b)k$
Extent of sliding = $(a_1/b_1)k - (a_2/b_2)k$

converted in proportion to the magnification ratio of the tube plate length seen on the radiograph and used as measured values.

5) Extent of sliding (Fig. 3)

The extent of sliding of the lag screw was determined by measuring the length of the lag screw protruding from the tube plate within the femoral head on sequential radiograph images taken beginning immediately after the operation until the completion of bone union using the methods of Doppelt[13] and Nakata[14]. The values obtained were converted in proportion to the magnification ratio of the tube plates seen on the radiographs and used as measured values. The difference between the values measured immediately after the operation and at the completion of bone union was defined as the extent of sliding. For subjects in whom the screw continued to slide and reached the structural limit of the CHS device, the limit was recorded as the measured value. There were no subjects in whom further sliding occurred after the completion of bone union. No subjects exhibited detectable differences in leg length caused by excessive sliding that affected gait ability.

6) Healing time

Bone union was judged to be completed and displayed as such when the disappearance of the fracture line and the bridging of trabecular bone were confirmed on sequential radiographs taken beginning after the operation. Bone union was verified by tomography in cases where the judgment was difficult to make solely based on plain radiographs. The number of days required for bone union was evaluated on a weekly basis.

7) Incidence of problematic deformity (leading to failure of fixation)

The incidence of problematic deformity (i.e., varus of the femoral head, flexion of the femoral head, cut-out of the femoral head, displacement at the fracture site, protrusion of the lag screw out of the femoral head, migration of the lag screw into the acetabulum, breakage of the CHS device, and subtrochanteric fracture) was evaluated based on sequential radiographs taken after the operation. Changes of 10° or more in comparison with radiographs taken immediately after the operation were defined as varus and flexion and changes of 4 mm or more were defined as displacement.

8) Successive general complications

Diseases occurring after hospital admission were counted.

6. Statistical analysis

Subjects were divided into 135° and 150° CHS groups and preoperative, intraoperative, and postoperative variables were compared between the two groups and statistical analysis was performed using the χ^2-test, Wilcoxon rank sum test (U test), and Student's t test (t test). P-values of less than 5% were considered statistically significant.

Multivariate analysis (MA) was performed for the variables for which significant differences were found in order to verify the results while avoiding confounding bias. In other words, MA was performed for, intra-operative, and postoperative variables for which significant difference was found as criterion variables, and for other variables as explanatory variables, to determine whether there were any effects attributable to the difference in screw-plate angle, i.e., use of 135° or 150°.

7. Rationale for setting sample size

It is preferable to achieve a shorter healing time in postoperative therapy that aims to regain the pre-injury levels of ambulatory ability by means of shorter treatment period and less medical expenditure. The post-operative X-ray examinations were implemented every week approximately and clinical significance was judged to be present if there was roughly a week to 10 days differences in the healing time. The estimated SD was 2.6 and the least detectable difference (the minimum difference which is significant to be detected) was 10 days (approximately 1.43 weeks) between the two groups.

Furthermore, since the ratio of the numbers of patients in the two groups was 1 : 2, the number of the two groups were decided as 1 : 2 (150° : 135°) instead of 1 : 1. Thus taking the above figures and the values of $\alpha = 0.05$, $\beta = 0.2$ (power = 0.80) into consideration, the sample size required was calculated to be 38 patients (150°) and 76 patients (135°). Hence, the sample size for this study is within the required

Table 2 Preoperative data

Variables	135° n = 83 (%)	150° n = 47 (%)	p value	
Sex			0.1905	χ^2 test
women	62 (74.7)	30 (63.8)		
men	21	17		
Age (y) mean ± SD	81.2 ± 6.87	78.2 ± 8.38	0.0678	U test
Cause of injury			0.1489	χ^2 test
at home	48 (57.8)	21 (44.7)		
away from home	35	26		
(in hospital)	(8)	(3)		
Days from (mean)				
fracture to ope	7.8 ± 16.16	6.8 ± 8.38	0.5767	U test *
hospital admission to ope	5.0 ± 2.74	6.1 ± 3.74	0.1498	U test *
General complications on admiddion			0.8879	χ^2 test
No. of patients	54 (65.1)	30 (63.8)		
No. of complications	74	38		
psychological	7	5		
visual disorder	5	1		
trauma	3	7		
knee osteoarthritis	8	3		
neurologic	12	5		
endocrine	4	4		
malignant tumor	2	1		
cardiovascular	23	8		
respiratory	5	0		
urinary	1	3		
gastrointestinal	3	1		
decubitus ulcers	1	0		
ASA score			0.8644	U test
Class 1	14 (16.9)	6 (12.8)		
2	40 (48.2)	27 (57.4)		
3	29 (34.9)	14 (29.8)		
4	0 (0)	0 (0)		
5	0 (0)	0 (0)		
Fracture type (Evans)			0.3628	χ^2 test
Stable Group 1	10 (12.1)	7 (14.9)		
2	39 (47.0)	24 (51.1)		
Unstable 3	25 (30.1)	8 (17.0)		
4	9 (10.8)	8 (17.0)		
Stable : Unstable	49 : 34	31 : 16	0.4358	χ^2 test
Bone density (Singh)			0.5704	U test
Grade 1	2	0		
2	3	4		
3	34	16		
4	36	20		
5	8	7		
6	0	0		

* : outlier

size.

Results

The results are shown in the Table 2-4 and there were no statistically significant differences found other than those shown below.

Variables for which there were significant differences between the 135° and 150° CHS groups (hereinafter referred to as "between the two groups"):

1. Operative time (Table 3)

Significant difference was revealed by the U test. Mean operative time was 92.1 minutes in the 135° CHS group and was longer in the 150° CHS group with 100.3 minutes. Evaluation performed by classifying the subjects' fractures as stable or unstable

Table 3 Intraoperative data

Variables	135° n = 83 (%)	150° n = 47 (%)	p value	
Type of anesthesia			0.2357	χ^2 test
General	24 (28.9)	18 (38.3)		
Spinal	59 (71.1)	29 (61.7)		
Operative time				
mean (min)	92.1 ± 23.24	100.3 ± 25.21	0.0354	U test *
Blood loss				
mean (cc)	191.4 ± 125.75	183.6 ± 123.31	0.7143	U test *

* : outlier

revealed that there were no significant differences between the two groups for stable fractures but that there were significant differences between the two groups for unstable fractures.

MA performed using operative time as a criterion variable revealed that the following factors affected operative time; ① screw-plate angle (longer operative time in the 150° CHS group), ② blood loss (greater blood loss with longer operative time).

2. Quality of fracture reduction (Table 4)

Significant difference was seen in nonanatomical reduction cases: the proportion of subjects with anteroposterior displacement was 24.5% in the 135° CHS group and fewer in the 150° CHS group with 8.6%; the proportion of subjects with extension was 37.7% in the 135° CHS group and higher in the 150° CHS group with 62.9%; and the proportion of subjects with lateral displacement was 34.0% in the 135° CHS group and smaller in the 150° CHS group with 11.4%.

MA revealed that the following factors affected the quality of fracture reduction: ① Evans classification (greater frequency of displacement/extension in the groups in the order of 1 to 4), ② age (greater frequency of displacement/extension with increasing age), and ③ screw position (greater frequency of displacement/extension in subjects with inadequate screw position).

3. Screw position (Table 4)

The proportion of cases with adequate insertion was 54.2% in the 135° CHS group and higher in the 150° CHS group with 76.6%. MA revealed that ASA score affected screw position (greater frequency of inadequate insertion with higher score).

4. Healing time (Table 4)

Healing was observed in all cases except 3 cases of death and 5 transferred cases occurred prior to confirmation of healing. The mean duration of healing time was 11.5 weeks (6.3-17.1 weeks) in the 135° CHS group and 9.7 weeks (6.0-17.3 weeks) in the 150° CHS group. MA revealed that the following factors affected healing time: ① screw-plate angle (shorter healing time in the 150° CHS group), and ② screw position (longer healing time in subjects with inadequate insertion).

Problematic deformity might affect the ambulatory ability and gait ability. But, MA revealed that problematic deformity did not affect the ambulatory ability and gait ability.

The difference in screw-plate angle did not affect the ambulatory ability and gait ability (data are not shown here).

Discussion

While there are numerous reports available regarding clinical results of the use of CHSs for the treatment of trochanteric fractures, there are few reports concerning screw-plate angle-based differences in clinical results. Koval[4] reported that the insertion of screws at an angle of 150° generates force that acts perpendicularly over the hips to promote sliding and impaction. However, it is difficult in clinical practice to insert screws into the center of the femoral head and neck, and the result may be superior insertion associated with a greater tendency for cut-out. Furthermore, the insertion point changes from metaphyseal bone to diaphyseal bone with 150° CHSs, and Koval indicated that there are no clinical reports indicating significant differences be-

Table 4 Postoperative data

Variables	135° n = 83 (%)	150° n = 47 (%)	p value	
Hospital stay (mean) (day)				
Duration of stay in orthopedic ward	93.4 ± 42.09	88.3 ± 28.42	0.4395	U test *
Duration of stay in hospital	104.2 ± 41.92	92.7 ± 30.26	0.0988	U test *
Duration of postoperative follow-up (mo)	4.9 ± 3.29	5.0 ± 2.65	0.3558	U test *
Quality of reduction			0.2138	χ^2 test
Anatomical	30 (36.1)	12 (25.5)		
Unanatomical	53	35		
A-P view			0.2835	χ^2 test
A-P reduction	22 (41.5)	17 (48.6)	0.5140	χ^2 test
Valgus	12 (22.6)	11 (31.4)	0.3585	χ^2 test
Varus	6 (11.3)	4 (11.4)	0.9876	χ^2 test
A-P displacement	13 (24.5)	3 (8.6)	0.0171	χ^2 test
Lateral view			0.0631	χ^2 test
Lateral reduction	7 (13.2)	5 (14.3)	0.8853	χ^2 test
Extension	20 (37.7)	22 (62.9)	0.0209	χ^2 test
Flexion	8 (15.1)	4 (11.4)	0.6238	χ^2 test
Lateral displacement	18 (34.0)	4 (11.4)	0.0169	χ^2 test
Screw position			0.0114	χ^2 test
Adequate	45 (54.2)	36 (76.6)		
Inadequate	38	11		
Distance of lag screw insert mean (mm)	7.3 ± 3.00	7.2 ± 3.17	0.4706	U test
Extent of sliding mean (mm)	5.5 ± 5.16	4.2 ± 4.28	0.1566	U test *
Healing time mean (weeks)	11.5 ± 2.59	9.7 ± 2.38	0.0001	U test *
Problematic deformity	7 (8.4)	2 (4.3)	0.7434	χ^2 test
Varus	4	1		
Flexion	0	1		
Displacement	3	0		
Successive general complications (occurring after hospital admission)				
No. of patients	33 (39.8)	15 (31.9)	0.3733	χ^2 test
No. of complications	42	16		
psychological (dementia)	17	5		
cardiovascular	2	2		
respiratory	5	2		
urinary	5	1		
gastrointestinal	1	1		
decubitus ulcers	5	0		
peroneal palsy	4	3		
others	3	2		

* : outlier, A-P: anteroposterior.

tween 135° and 150° CHSs.

There have been several reports on studies performed on the effects of the use of different screw-plate angles using cadavers. Den Hartog[15] and Meislin[5] reported that although the use of 150° CHSs in unstable fractures promotes sliding, these CHSs do not improve the stability of the fracture, and the difficulty of inserting CHSs into the center of the femoral head and neck creates a tendency for superior cut-out. Kyle[16] reported that while higher screw-plate angles increase the stability of the fracture site, such insertions are more difficult, and the advantage of the use of lower screw-plate angles lies in their ease of insertion.

In this study, significant differences between the two groups were seen for the four items: operative time, quality of fracture reduction, screw position, and healing time. No significant differences were

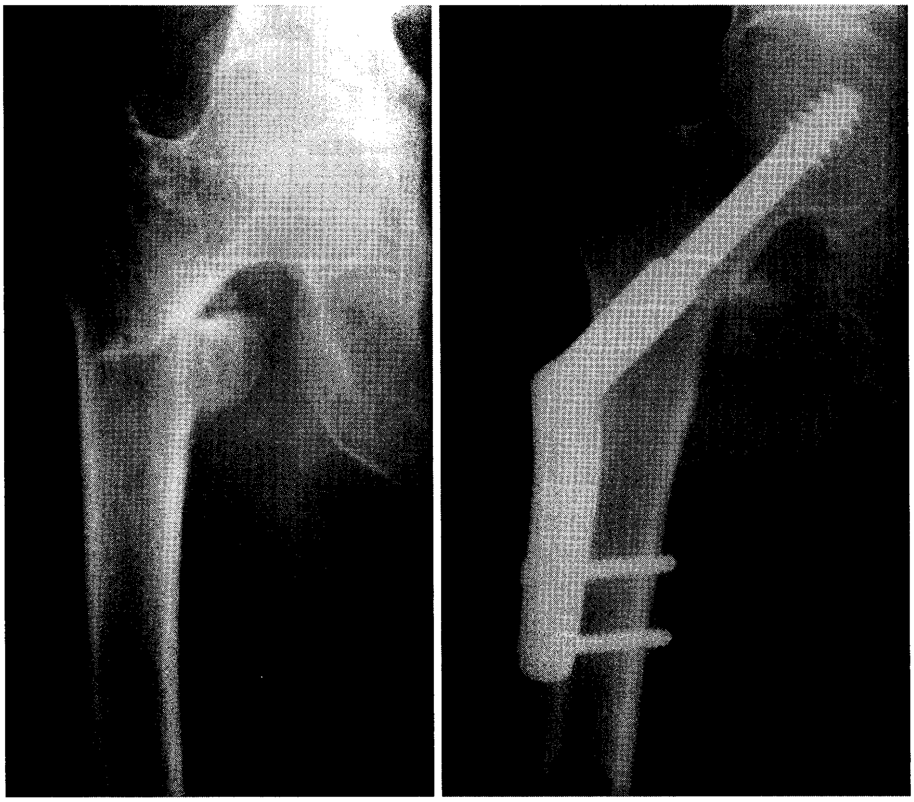

Fig. 4 Radiograph 135° CHS

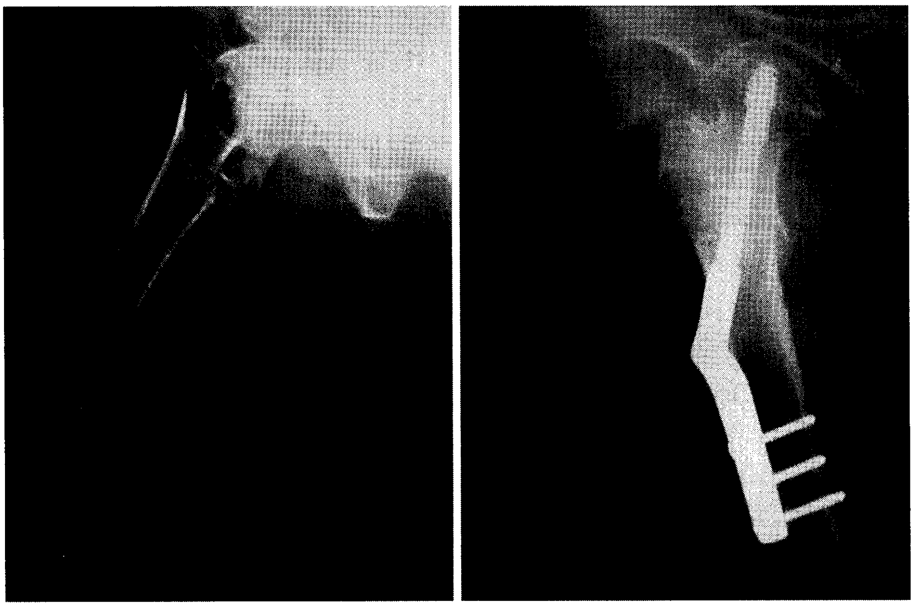

Fig. 5 Radiograph 150° CHS

found in the two items which are in extent of sliding and incidence of problematic deformity (leading to failure of fixation), for which differences could be expected from a theoretical perspective and based on various nonclinical reports. These six variables are discussed in greater detail below.

Operative time

Based on various references and reports, mean operative time for this procedure ranges from 34 to 122 minutes[18,19]. The use of 135° CHSs is more common and only one report described combined use of 135° and 150° CHSs. In the present study, operative time was an average of 8.2 minutes longer with the use of 150° CHSs than with the use of 135° CHSs. This, combined with the fact that MA revealed that operative time is affected by blood loss and screw-plate angle, suggests that surgery performed with 150° CHSs is more difficult, and this is borne out by the fact that ingenuity and experience were required during the actual operations. For example, when a convex deformity can not implement reduction on the lateral side, it had to be pushed and held upwards by assistants while the surgeon inserts the guide pin, drills a hole, and then inserts the lag screw onto the pin. In addition, while the guide wire is inserted into metaphyseal bone with 135° CHSs, the wire is inserted obliquely into harder diaphyseal bone with 150° CHSs, making the procedure more difficult despite the use of an insertion guide.

MA performed using operative time as a criterion variable revealed that the difference of operator did not affected operative time.

It seems to be discrepant between the operative time and the blood loss. But, there was no significant difference in blood loss between 135° and 150°. MA revealed that the following factors affected operative time ① blood loss at the first, ② screw-plate angle at the second. Screw-plate angle did not affect blood loss. It is thought that 150° screw-plate angle affected operative time because of high technique.

Quality of reduction

Den Hartog[15] pointed out the importance of medial cortical bone reconstruction based on the results of studies performed in cadavers. There are many reports of clinical studies indicating the importance of alignment and apposition[4,12,13], and many reports recommend the use of anatomical and valgus reduction as alignments as it is difficult to insert a screw from the femoral head to the center of the neck using other alignments[1]. There are also many reports that state the importance of the continuity of medial cortical bone in anteroposterior view and continuity of posterior cortical bone in lateral view as apposition[1,10,11].

In the present study, the incidences of anteroposterior displacement and lateral displacement in nonanatomical reduction cases were higher with the use of 135° CHSs and the incidence of extension in lateral view was higher with the use of 150° CHSs. There were no results to indicate that the incidence of valgus is significantly higher with the use of 150° CHS. MA revealed that Evans classification and screw position affected quality of fracture reduction; this is thought to be consistent with other reports indicating that screw position is more likely to be inadequate in cases of unstable fracture with incomplete reduction[19].

Screw position

Wu[20] reported based on studies performed in cadavers that screw insertion should be made inferiorly in anteroposterior view and centrally in lateral view, while Den Hartog[15] reported that central insertion in both anteroposterior and lateral views is important in terms of the stability of the fracture site. In clinical reports as well, it has been suggested that insertion made centrally or slightly inferiorly in anteroposterior view and centrally in lateral view are appropriate for screw implantation. Among these reports, however, few describe the use of screw-plate angles of 140° or greater. In studies performed in cadavers, as reported by Kyle[16] and Meislin[5], it is generally recognized that insertion using an angle of 150° is more difficult than insertion using an angle of 135°. However, Parker[19] reports that screw position is related to the quality of fracture reduction. In this study, the proportion of subjects receiving adequate insertion was higher in the 150° CHS group. This could have been a reflection of the difference between experiments and the clinical settings, where reduction procedures can be performed for better insertion points.

MA revealed that the screw position was affected by ASA score, this is thought that high ASA score resulting from some health abnormalities on admission reflect osteoporosis and incomplete reduction, and it might result in inadequate screw position.

Healing time

The few reports mentioning healing time indicate mean healing times ranging from 8.1 to 11.0 weeks[2,3,14,21]. There are only two reports on the use of 135° and 145° screw-plate angles. It is thought that 150°, a high angle, is closer to the direction of the weight-bearing line than 135°, a low angle, and enhances the dynamic impaction generated at the fracture surface, resulting in the promotion of bone union. In this study, healing time was shorter with the use of 150° CHSs than with 135° CHSs, supporting the hypothesis that 150° CHSs are more effective for the promotion of bone union than 135° CHSs. MA revealed that healing time is affected by screw position and screw-plate angle, and it was thought that insertion at an adequate position with the use of 150° CHSs resulted in shorter healing times.

This study suggests that with the CHS method, the 150° CHS with shorter healing period is preferred.

Extent of sliding

Reporting on studies performed in cadavers, Meislin[5] indicated that 150° CHSs slide significantly more than 130° and 140° CHSs and Kyle[16] indicated that greater force is required to induce sliding with 130° CHSs than with 150° CHSs. On the other hand there are clinical reports indicating that there are no differences in the extent of sliding between 135° and 145° CHSs[21][22].

In the present study, no significant differences were found in the extent of sliding between the two groups, even when subjects' fractures were classified into stable and unstable types. These results are thought to reflect the marked differences in conditions that exist between studies performed in cadavers and clinical studies. MA revealed that the extent of sliding was affected by Evans classification but not by screw-plate angle.

Incidence of problematic deformity

Based on the results of a cadaver study, Wu[20] reported that migration of the femoral head decreases when screw position compared to the femoral head is inferior in the anteroposterior view and central in the lateral view. Clinically, there are reports stating that with inadequate screw position, inadequate distance of lag screw implant, and inadequate reduction, varus in particular, excessive sliding occurs in relation to the degree of osteoporosis and results in deformities that become problematic postoperatively, including cut-out[1][22]~[24]. In this study, no significant differences were found in the incidence of problematic deformity between the two groups, even when the subjects' fractures were classified into stable and unstable types. It is suspected that, despite the use of CHSs with two screw-plate angles for which differences in sliding ability have been demonstrated in cadaver studies, there were no significant differences in the incidence of postoperative problematic deformity because of the differences in conditions such as operative procedures and postoperative treatment in cadaver and clinical studies.

MA revealed that the incidence of problematic deformity was affected by extent of sliding (incidence increases with extent) and cause of injury (higher incidence for injuries sustained at home). One possible explanation for the difference associated with the cause of injury is that individuals who sustain injuries outside of the home tend to be more active and are thus associated with a lower degree of osteoporosis.

Conclusion

Having completed a comparative analysis on the clinical results of CHSs inserted at angles of 135° and 150°, significant differences between them were found for the following variables: ① operative time, ② quality of fracture reduction, ③ screw position, and ④ healing time. Among these four variables, significant differences resulting from differences between the CHS angles were found for operative time and healing time. Operative time was 8.2 minutes. longer as an average and healing time was 1.8 weeks shorter in average in the 150° CHS group compared with the 135° CHS group. There were no significant differences in extent of sliding and incidence of problematic deformity, for which differences had been reported in earlier experimental studies, nor were these two variables affected by screw-plate angle. Therefore, it was concluded that with the CHS method, the 150° CHS with a shorter healing period is preferred where possible.

Acknowledgement

The author wishes to thank Dr. Ken-ichi Adachi and Mr. Atsushi Katoh for their valuable guidance, particularly with the statistical analysis.

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高齢者大腿骨転子部骨折の compression hip screw 方法
—固定角度の治療結果への影響—

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大腿骨転子部骨折に対する low angle compression hip screw（135° CHS）法と high angle compression hip screw（150° CHS）法の治療結果の比較を目的とした．CHS 方法を用いた 60 歳以上の患者（135° CHS 群 83 例，150° CHS 群 47 例）を対象とした．術前と術後の X 線検査所見などの諸項目，手術中の諸項目について評価検討を行った．評価項目について両群を比較するにあたり，多変量間の交絡などの bias を回避するために多変量解析も援用して統計学的に解析した．その結果，①手術時間，②整復状態，③screw の骨頭内刺入位置，④骨癒合期間の 4 項目で 135° CHS 法と 150° CHS 法間に有意差が見られた．4 項目のうち 135° と 150° の角度の差が影響していた項目は，手術時間と骨癒合期間であった．理論上および諸家の実験的研究からも，両群で有意差の生じることが予想される sliding 距離と問題となる変形の発生では有意差は見られず，135° と 150° の角度の差も影響していなかった．