A new technique for lag screw placement in the dynamic hip screw fixation of intertrochanteric fractures: decreasing radiation time dramatically

Wei-Chao Sheng • Jia-Zhen Li • Sheng-Hua Chen •
Shi-Zhen Zhong

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Abstract The goal of this study was to confirm the decrease in radiation time required for a new technique to place dynamic hip screws (DHS) in intertrochanteric fractures. Seventy-six patients were treated with DHS by either the new technique (NT) or the conventional technique (CT). The width of femoral shaft, the length of the hip screw to be implanted into the injured side, and the distance between the tip of the greater trochanter and the entry point of the guide wire were measured at the uninjured side on the anteroposterior pelvic radiograph preoperatively, and the actual width of the injured femoral shaft was measured intra-operatively. Finally, the entry point and the length of hip screw were obtained through an equation. Mean radiation time of the NT patients (24.57 ± 7.80 s) was significantly shorter than the CT patients (54.2 ± 18.26 s) ($P < 0.001$). The new technique decreased radiation time dramatically in DHS fixation.

Résumé Le but de cette étude est d'évaluer la diminution du temps d'exposition aux rayons X par une nouvelle technique de vissage dynamique de la hanche DHS (NT) comparée à la technique conventionnelle. Matériel et méthode: 76 patients ont été traités par DHS avec cette nouvelle technique (NT) ou la technique conventionnelle (CT). La largeur et la longueur de la vis fémorale implantée

et la distance entre le sommet du grand trochanter et le point d'entrée du guide ont été mesurés du côté fracturé par une radiographie de face pré-opératoire et per-opératoire. Finalement, le point d'entrée et la longueur de la vis fémorale sont obtenus par équation. Résultats : l'exposition moyenne aux rayons X de la nouvelle technique (24.57 ± 7.80 s) a été significativement moins importante que dans la technique conventionnelle (54.2 ± 18.26 s) ($P < 0.001$). En conclusion, cette nouvelle technique permet de diminuer le temps d'irradiation de façon importante, lors d'une fixation de fracture fémorale par DHS.

Introduction

Since a variety of sliding hip screw and plate devices were invented in the 1950s by Massie et al. [17, 22], the DHS has become a standard fixation device for intertrochanteric fractures [2, 14, 18]. The crucial part of the DHS operation is insertion of a hip screw into the femoral neck in an exact position. It is strange that no previous literature related to the DHS exactly describes the entry point of a hip screw [10, 19, 20]. Some authors locate the entry point at approximately 2 cm below the vastus lateralis ridge [13, 14], but since their location failed to present a definite osseous landmark, it could not be used intra-operatively without an image intensifier. In addition, repeated attempts to optimise the guide wire position will undoubtedly increase the exposure to radiation hazards and bring about frustration to the operation theatre staff. Adams [1] used staples as groin skin markers to guide the placement of the DHS guide wire. This is a less accurate technique, as the reference radiopaque staples will inevitably move when the reduction is made and traction is applied to the skin edges. Aronsson and Carlsson [3] used a marker pen

W.-C. Sheng • S.-H. Chen • S.-Z. Zhong (✉)
Department of Anatomy, Southern Medical University,
510515 Guangzhou, China
e-mail: shengdoctor@126.com

J.-Z. Li
Department of Orthopaedics,
The First Affiliated Hospital of Zhengzhou University,
450052 Zhengzhou, China

Fig. 1 The anteroposterior pelvic radiograph is used for measurement preoperatively. Line MN indicates the femoral shaft width just below the lesser trochanter, line EF is the length of the hip screw to be implanted into the injured side in relation to the femoral neck width (NW), and line GE is the distance between the tip of the greater trochanter and the entry point. Point O is at the middle of NW , and the angle (α) is equal to the plate angle in all cases. The distance between the centre of the auricular surface of the femoral head to point F is 10 mm

instead of staples in the treatment of slipped femoral epiphysis but found similar disadvantages. Then Schep [21] and Browbank [5] further described in vitro techniques using fluoroscopy-based navigation to estimate the position of the guide wire in the DHS fixation. They showed good outcome in vitro, but this method is clearly technically and financially demanding. Later, Haydar [9] drew simulated DHS hardware on the image intensifier screen using size A4 plain folded paper. But this method did not dramatically decrease the dependence on X-ray use.

In our clinical practice, we invented a practical technique to resolve the above-mentioned problems. The aim of this prospective study was to verify the decrease in radiation time of our location method in a clinical setting.

Materials and methods

Patients

Seventy-six consecutive patients with intertrochanteric fractures (AO 31.A1-A2) agreed to participate in the study between June 2003 and May 2005. Exclusion criteria were reverse obliquity fractures (AO 31.A3), previous fractures, or operations involving hip, bilateral intertrochanteric fractures, and patients with deformities of the proximal femur. They were randomly divided into the NT and CT groups. The following patient details were recorded preoperatively: age and gender, mean body weight, average

stature, injury side, mean preoperative haemoglobin, and fractures classification.

Surgical techniques

The conventional operative technique of DHS has been described previously [7, 12]. The new technique is described below.

Initially, three crucial measurements were carried out at the uninjured side on the anteroposterior pelvic radiograph preoperatively (Fig. 1). The geometric parameters of proximal femur included femoral shaft width just below the lesser trochanter (MN), length of the hip screw to be implanted into the injured side (EF), and the distance between the tip of the greater trochanter and the entry point (GE). The femoral neck width (NW) was defined as the shortest distance within the femoral neck perpendicular to the femoral neck axis (Fig. 1) [8, 11]. All measurements were performed by a highly experienced senior surgeon with a ruler.

Patients were operated upon as soon as their clinical conditions were stable. Under anaesthesia, surgery was performed with the patients in the supine position. A lateral approach to the proximal femur was used to expose the greater trochanter, fracture lines, and the lesser trochanter. The fracture was first reduced anatomically. Temporary fixation of the fragments was obtained with 2.0-mm Kirschner wires. Next, a sliding caliper was used to measure the actual femoral shaft width just below the lesser trochanter ($M'N'$) in vivo (Fig. 2). Finally, the

Fig. 2 Intra-operative measurements carried out on the femur in vivo. Line $E'F'$ stands for the length of the hip screw to be inserted, line $G'E'$ for the distance between the tip of the greater trochanter and the entry point of the guide wire, and line $M'N'$ for the femoral shaft width just below the lesser trochanter

unknown values of $E'F'$ and $G'E'$ to be used for operation were calculated through the equation:

$$\frac{EF}{E'F'} = \frac{GE}{G'E'} = \frac{MN}{M'N'}$$

The value of $E'F'$ determines the length of the actual hip screw to be used, and the value of $G'E'$, indicating the distance between the tip of the greater trochanter and the entry point of the guide wire in the lateral plane of the femur, determines the actual entry point of the guide wire in the lateral plane, point E' , which should be located at the middle of the femur in the sagittal plane (Fig. 2).

After localisation of the entry point, the guide wire was inserted into the neck by the length of $E'F'$ under the guidance of the DHS aiming device. At this point, the reduction of the fracture and position of the guide wire were checked under the image intensifier on both lateral and anteroposterior views. When the reduction was considered satisfactory and the position of the guide wire was acceptable, the operation would be accomplished according to the conventional steps. Otherwise, adjustments were made until satisfactory reduction and fine positioning were achieved.

Two image intensifiers were used. The equipment automatically measured and displayed the radiation time in seconds at the end of each operation. The value was routinely recorded in the image intensifier record book. The following surgical details were recorded: time from injury to operation, type of anaesthesia, duration of operation, radiation time, intra-operative complications or technical difficulties, duration of hospital stay, and patients needing transfusion.

Postoperatively, all patients were managed in an identical manner with prophylactic antibiotics for 72 h. Partial weight bearing was routine at least 5 weeks after operation. Full weight bearing was allowed depending on individual clinical condition. Haemoglobin levels were checked at 24 h and at 7 days postoperatively. If haemoglobin was lower than 90 g/l. Blood transfusion was considered.

Follow-up was scheduled at 4, 8, 16 weeks, 6 months, and 12 months after the operation. Plain radiographs were taken at each follow-up visit. Radiographic healing was interpreted by the attending surgeon at each follow-up. If radiographs taken at the 8th week showed maintenance of the implant position and no loss of reduction, patients were allowed to progressively increase weight-bearing as tolerated. The position of the lag screw was assessed on standardised post-operative X-rays using Baumgaertner's Tip-Apex distance method [4]. Functional outcome was assessed by the Barthel Index [15].

Statistics

For statistical analysis we used the Student *t* test and chi-square test. SPSS 13.0 statistical software was used to analyse the data. *P* value below 0.05 was considered to be significant.

Results

There were 40 patients in the NT group and 36 in the CT group. The characteristics of the two treatment groups are presented in Table 1, demonstrating their similar characteristics.

Operative data of the patients are summarised in Table 2. Mean radiation time of the NT patients (24.57 ± 7.80 s) was significantly shorter than the CT patients (54.2 ± 18.26 s) ($P < 0.001$). But the mean duration of operation for the NT group was 56.9 min and was not significantly greater than that for the CT group ($P = 0.426$). There were no intra-operative complications nor technical difficulties in the CT group. On the other hand, there were two types of difficulties in the NT group: the disparity between the actual length of lag screw and its theoretical value, and the disparity between the actual $G'E'$ and its theoretical value. There were two patients with disparity of lag screw length and one patient with disparity of entry point. Lastly, the operations of the three patients were accomplished under image intensifier monitor without using the new technique. Blood transfusions were required in ten of the NT patients and 12 of the CT patients, while the amount of packed cells needed in both groups was not statistically significant.

Table 1 Patient data in two groups

	NT (<i>n</i> =40)	CT (<i>n</i> =36)	<i>P</i> value
Mean age (y)	70.1±10.01	66.3±10.78	0.108 ^a
Gender			0.981 ^b
Female	19	17	
Male	21	19	
Mean body weight (kg)	60.0±9.46	61.4±7.92	0.492 ^a
Average stature (cm)	165.5±7.01	167.7±7.18	0.177 ^a
Side			0.628 ^b
Right	20	20	
Left	20	16	
Mean preoperative haemoglobin (k/l)	133.1±17.90	129.0±18.83	0.327 ^a
Fracture classification			0.790 ^b
AO 31.A1	19	16	
AO 31.A2	21	20	

^a Student's *t* test

^b Chi-square test

Table 2 Operation and hospital data in two groups

	NT (n=40)	CT (n=36)	P value
Mean time from injury to operation (days)	6.6±5.54	7.0±5.94	0.761 ^a
Type of anaesthesia			0.679 ^b
General	23	19	
Spinal	17	17	
Duration of operation (min)	56.9±10.03	59.1±13.30	0.426 ^a
Radiation time (s)	24.57±7.80	54.2±18.26	<0.001 ^a
Intraoperative complications or technical difficulties			0.245 ^b
Disparity of lag screw length	2	0	
Disparity of entry point	1	0	
Duration of hospital stay (days)	12.5±4.52	11.1±4.20	0.155 ^a
Patients needing transfusion			0.689 ^b
2 units	6	8	
>2 units	4	4	

^a Student's *t* test^b Chi-square test

Thirty-five of the original 40 patients (87.5%) in the NT group and 32 of the original 36 (88.9%) in the CT group underwent follow-up. The follow-up rate was not significantly different ($P=0.852$) between the groups. Two out of 35 (5.7%) patients treated with NT and one out of 32 (3.1%) patients treated with CT died before the final follow-up. The mortality rate was not significantly different ($P=0.609$) between the groups. The causes of death were not directly related to their hip fractures. Two implant failures occurred in the NT group. Screw cut-out from the femoral head occurred in one patient and severe medial displacement in another. In the CT group, there was one case of screw cut-out and another case of deep wound infection resulting in sepsis requiring DHS removal, antibiotic treatment, and refixation. All of these four cases were treated by reoperation using AO-ASIF proximal femoral nail and healed uneventfully. Failure rates were similar in the two groups. All other fractures healed within 6 months. X-ray evaluation 6 months after operation revealed the mean tip-apex distance in the two groups was not significantly different. Functional outcome was assessed by the Barthel Index 12 months after operation. Mean scores in the NT and CT groups were 93.3 and 95.3, respectively. Differences in mean hip score between the two groups were not significant ($P=0.164$).

Discussion

The DHS has become the most commonly used device for intertrochanteric fractures in many hospitals [2, 14, 18].

The C-arm image intensifier monitor is necessary for orthopaedic surgeons to check the reduction of fracture and the position of guide wire or hip lag screw in the femoral neck. Prior to conventional DHS fixation, as surgeons usually have no idea of the exact entry point of the guide wire and the length of the hip lag screw, they have to spend much time determining the entry point and the length of lag screw with repeated guidance of an image intensifier. Thus, operating surgeons and theatre staff are exposed to significant radiation. Several techniques have been described for accurate guide wire placement in DHS fixation [1, 3, 5, 9, 21], but they did not decrease the dependence on X-ray dramatically. The most significant improvement that our new method has made in this study for DHS fixation is that it can, in most cases, determine not only the exact lateral cortex entry point of hip lag screw but also the precise length to be implanted into the femoral neck. In our study, mean radiation time of the NT patients (24.57±7.80 s) was significantly shorter than the CT patients (54.2±18.26 s) ($P<0.001$). Although this method could not be used successfully in three patients in the NT group, we believe it is an effective, simple method to decrease radiation time dramatically.

The design of the measurement method mentioned above stemmed from our extensive daily clinical practice and was aimed at the practical problems in DHS operation. It developed on the basis of two theoretical points. First, our equation is valid, because it keeps constant magnification in calculation according to the same radiograph. It is common sense that different conditions and positions, especial the distance between body and X-film, in taking radiographs will result in different magnifications. It is, therefore, difficult to have a precise assessment of the magnification of a given X-film. Consequently, it is often very difficult to determine the actual length of the lag screw and the entry position of guide wire from a standard X-film. On the contrary, in our method, we can get the exact magnification by calculation (using the equation provided), with the parameters obtained from the preoperative radiographic measurements and from intraoperative measurements. With exact estimation of the magnification, it is possible to determine the length and the position we need for the DHS fixation. Secondly, the central implantation of the lag screw in the femoral neck can also be ensured by our method. Previous studies have used a subjective assessment, dividing the femoral head into superior, central, and inferior segments for the anteroposterior view and anterior, central, and posterior segments for the lateral view. Davis et al. [6] recommended the central position on both views. Then Baumgaertner argued the central fixation and described the Tip-Apex distance method [4]. Moreover, Mains and Newman [16] and Thomas [23] considered that a central or inferior position on the anteroposterior view

was best. Therefore, in the measurement design we have set the screw at the central position on the anteroposterior and lateral views. At the same time, a 10-mm distance is usually desirable to secure a good screw position in the subchondral bone. This is why we set point F about 10 mm below the articular surface of the femoral head on the X-ray film during the preoperative measurement.

With regard to the three patients in the NT group in whom the new technique could not be used successfully, there are three aspects which must be addressed. The first question involves an adequate exposure of the tip of the trochanter. Since this region is covered with massive tendon, fascia, and thick periosteum, an inexact measurement of G'E' is likely to result from the poor exposure of the cortical bone. The second problem relates to an anatomical or a near-anatomical reduction of the intertrochanteric fracture. An adequate reduction is a prerequisite for the application of our method, especially when the lesser trochanter is involved or the basal region is severely damaged. Under poor reduction, it is impossible to determine an ideal entry point and a suitable length of the hip lag screw. In this study, our method failed in three cases, possibly because their fractures of lesser trochanter could not be reduced anatomically so that the measurement of M'N' could not be conducted accurately. Moreover, fractures of the greater trochanter should also be reduced anatomically as much as possible. Otherwise, the difficulty of measuring G'E' will likely lead to an inaccurate entry point. In our study, the disparities between the actual entry point and the theoretical value may possibly result from poor reduction of the greater trochanter. The third aspect deals with osteoporosis in the patient which should be taken into consideration preoperatively. Femoral intertrochanteric fractures usually occur in elderly patients, often complicated with a certain degree of osteoporosis. Excessive axial telescoping will shorten the length of the femoral neck. Accordingly, the hip lag screw should be shorter than the theoretical length.

This study met with the challenge that is often encountered when treating intertrochanteric fractures with a sliding hip screw. The weakness of this study is the evaluation of the X-ray. Radiation time is used as a parameter to estimate the radiation exposure to the patient and the staff in fluoroscopically guided procedures and operations. But there is poor correlation between radiation time and dose as radiation dose depends on number of technical parameters such as X-ray beam energy, intensity, orientation, field size, and skin-source distance. Consequently, we need to adopt some good and practical tools for estimating radiation exposure in any forthcoming study.

In conclusion, the new technique for lag screw placement in the DHS fixation of intertrochanteric fractures provides traumatic and orthopaedic surgeons with neces-

sary parameters which can direct the insertion of the guide wire. The new technique as opposed to the conventional technique can decrease radiation time dramatically.

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