International Orthopaedics (SICOT) (2006) 30: 26–30
DOI 10.1007/s00264-005-0032-4

ORIGINAL PAPER

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Study of hip joint dislocation after total hip arthroplasty

Received: 15 September 2005 / Accepted: 26 September 2005 / Published online: 13 December 2005

Abstract The present study was undertaken to identify the factors responsible for hip joint dislocation after total hip arthroplasty, laying emphasis on analysis of the background variables of the patients. Of the 317 hips included in the study, ten (3.2%) dislocated. Only the anteversion angle of the cup differed significantly between the dislocation group and the dislocation-free group. The safe zone of the anteversion angle seems to be between 20° and 30°, but it is also essential to set the antetorsion angle of the stem to match the shape of individual bones to create a more stable hip joint. This safe zone may be expanded by the additive effect of antetorsion angle of the stem.

Résumé Le but de cette étude a été d'identifier les facteurs responsables d'une luxation de la hanche après arthroplastie totale en insistant sur l'analyse des différents paramètres de chaque patient. Sur les 317 hanches incluses dans cette étude, 10 (3,2%) ont présenté une luxation. La seule différence significative entre le groupe des sujets ayant présenté une luxation et ceux n'en ayant pas présenté est l'angle d'antéversion de la cupule. L'angle optimum d'antéversion de la cupule semble être compris entre 20 et 30 degrés mais il est également essentiel de lier l'angle d'antéversion avec l'angle d'antétorsion de la pièce fémorale, celles-ci ayant été manufacturées sur mesure et adaptées à la géométrie osseuse de chaque individu de façon àcréer une hanche parfaitement stable. Cette zone de sécurité peut être améliorée par l'addition, à l'angle d'antéversion de la cupule de l'angle d'antétorsion de la pièce fémorale.

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Introduction

Dislocation occurring after total hip arthroplasty can cause great pain and mental stress to the patient. This type of dislocation tends to be repeated and can destroy parts of the hip prosthesis, leading to functional deterioration of the prosthesis. To reduce the frequency of such dislocation, it is essential to clarify the factors predisposing to its occurrence. The present study was undertaken to identify the factors responsible for hip joint dislocation after total hip arthroplasty, laying emphasis on analysis of the patients' background variables (especially the component alignment).

Subjects and methods

The subjects of this study were 266 patients (317 hips in total) who were followed up for 5 years or more after primary total hip arthroplasty (THA) carried out for osteoarthritis of the hip between 1989 and 2000. The patients ranged in age from 23 to 84 years (mean 61.6 years). There were 55 men and 211 women, and the follow-up period ranged from 5.0 to 14.7 years (mean 8.0 years).

The prosthesis used was a product of Biomet, Inc. (Warsaw, IN, USA) in all subjects. In all 317 hips the stem used was a Bi-Metric stem (neck–shaft angle 135°; with no antetorsion angle; one quarter of the central part was porous-coated). The cup was a Mallory–Head finned porous cup for 162 hips and a metal-back cup for 155 hips. These cups had a 5-mm-high wall in the range of 120° on the open plane of the cup. The head diameter was 28 mm and the oscillating angle was 103° in all cases. The posterior approach was used and the joint capsule was resected in all cases. The short external rotator muscles were re-sutured.

Postoperative rehabilitation in the sitting position was started one week after the operation in all cases, and rehabilitation involving walking on the feet was started two weeks after the operation.

In all these cases, the age, sex and body weight of the patients, the abductor muscle strength, inclination angle of

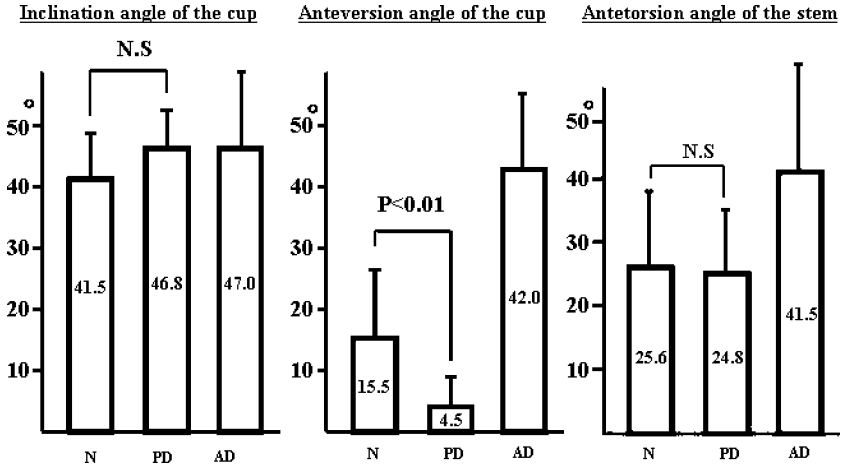

Fig. 1 Prosthesis setting angles (*N* dislocation-free group, *PD* posterior dislocation group, *AD* anterior dislocation group)

the cup, anteversion angle of the cup, antetorsion angle of the stem, and upper and lower deviation of the head center and the greater trochanter tip were analyzed to identify the cause of the dislocation. The abductor muscle strength was evaluated manually preoperatively. The inclination angle of the cup was defined as the angle formed by the line connecting the two teardrops and the line connecting the upper and lower end of the open plane of the cup on a frontal radiograph. The anteversion angle of the cup was measured by the method of Lewinnek [4], using the following equation:

$$\sin\beta = b/a,$$

where a indicates the maximum vertical dimension on the open plane of the cup that passes through its center, b indicates the length of the line passing through the center and perpendicular to the aforementioned line, and β denotes the anteversion angle of the cup. The antetorsion angle of the stem was measured according to the method of Shirasu et al. [7], in an axial radiograph of the anterior plane of the knee taken at an angle of 45° to the femoral axis; the angle was calculated using the following equation:

$$\tan\theta o = 2\sin\theta a/(1+\cos\theta a)^2,$$

where θo indicates the apparent antetorsion angle of the stem, and θa denotes the true antetorsion angle of the stem. The upper and outer deviation of the head center were calculated using the following equations:

$$\text{Upper deviation} = (ca/L/2),$$

$$\text{Outer deviation} = (cl/L/2),$$

where c indicates the head center, L denotes the distance between the tear drops, ca indicates the length of a line drawn perpendicular from c to the line connecting the two

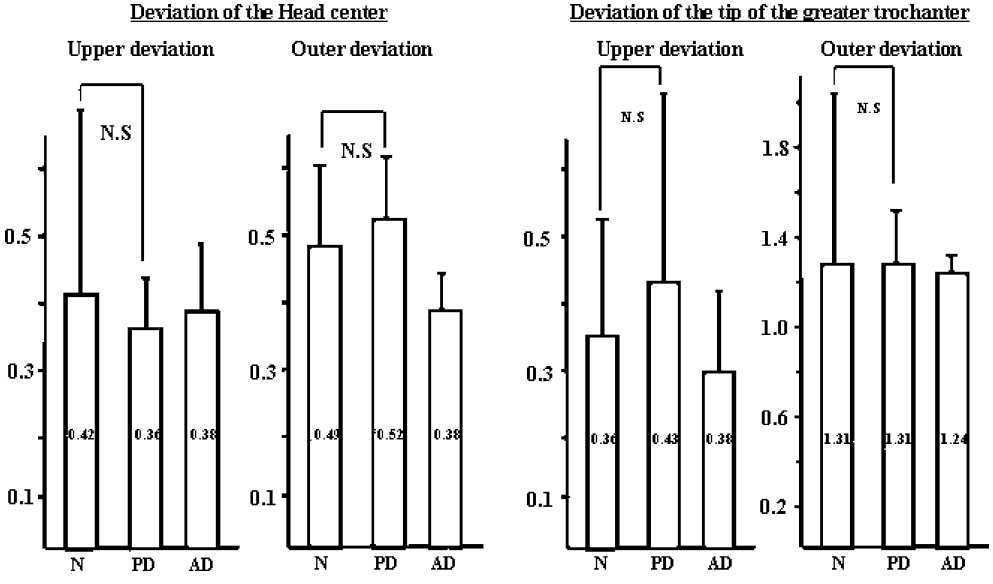

Fig. 2 Deviation of the head center and tip of the greater trochanter (abbreviations as in Fig. 1)

teardrops, and *cl* represents the length of a line drawn perpendicular from *c* to a line drawn from the lower end of the postoperative teardrop perpendicular to the line connecting the two teardrops.

The upper and outer deviation were also expressed by the following equations, in which *t* denotes the tip of the greater trochanter:

$$\text{Upper deviation} = (ta/L/2),$$

$$\text{Outer deviation} = (tl/L/2),$$

Each of the parameters was compared between the dislocation group and the dislocation-free group. The significance of inter-group differences in these parameters was tested using the χ^2 test and the Mann–Whitney U test. $P<0.05$ was regarded as denoting statistical significance.

Results

Of the 317 hips included in the study, ten (3.2%) dislocated (posterior dislocation in eight hips and anterior dislocation in two hips). Of these ten hips, eight had dislocated within three months after the operation. Repeated dislocation was seen in two hips in which the first dislocation had occurred within one month after operation and in one hip in which the first dislocation had occurred within three months after operation. In all of these three hips, the dislocation was posterior. Anterior dislocation was seen in two hips (one of these developed dislocation immediately after the operation and in the other, dislocation occurred two days after the operation). Recurrent dislocation was not seen in any of the cases with anterior dislocation of the hip.

The mean age of the patients did not differ significantly between the dislocation-free group (mean±SD=61.7±10.9 years) and the dislocation group (59.1±6.7 years). The male-to-female ratio did not differ significantly between the dislocation-free group (male:female=58:249) and the dislocation group (3:7). The body weight did not differ significantly between the dislocation-free group (53.6±9.3 kg) and the dislocation group (60.4±12.4 kg). The abductor muscle strength did not differ significantly between the dislocation-free group (3.90±0.67) and the dislocation group (4.0±0.38).

The inclination angle of the cup was 41.5±8.7° in the dislocation-free group, 46.8±6.5° in the posterior dislocation group, and 47.0±12.7° in the anterior dislocation group. This parameter did not differ significantly between the dislocation-free group and the posterior dislocation group. The anterior dislocation group was not included in the statistical test for determining the significance of inter-group differences, since this group included only two hips.

The anteversion angle of the cup was significantly smaller in the posterior dislocation group (4.5±6.6°) than in the dislocation-free group (15.5±11.9°) ($P<0.01$). This angle was, however, rather large in the anterior dislocation group (42.0±12.7°). The antetorsion angle of the stem did not differ significantly between the dislocation-free group (25.6±11.7°) and the posterior dislocation group (24.8±

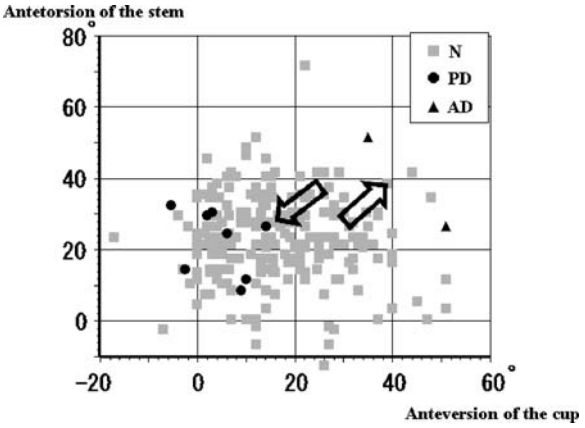

Fig. 4 Relationship of dislocation to the anteversion angle of the cup and the antetorsion angle of the stem (abbreviations as in Fig. 1)

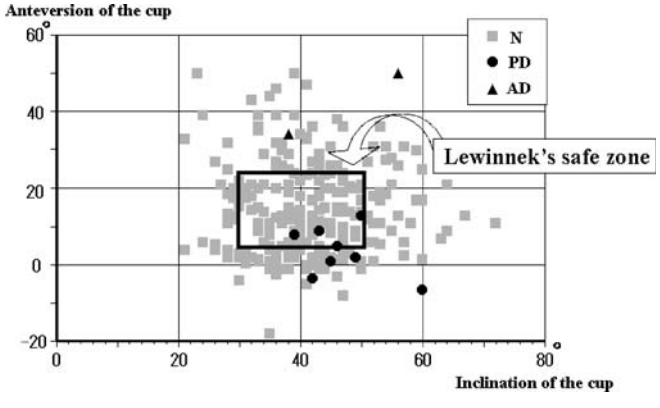

Fig. 3 Relationship of dislocation to the inclination and anteversion angles of the cup (abbreviations as in Fig. 1)

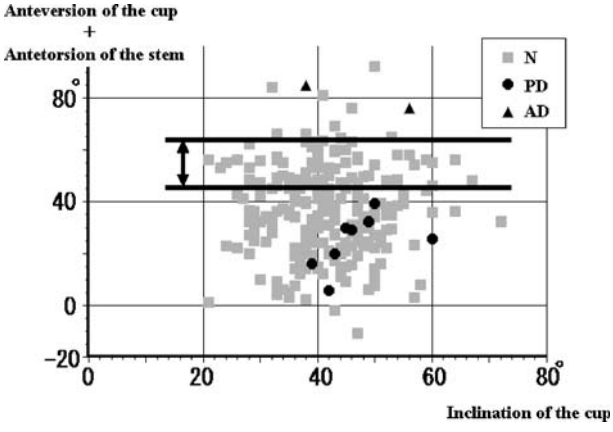

Fig. 5 Relationship of dislocation to the inclination angle and the sum of the anteversion angle of the cup and the antetorsion angle of the stem (abbreviations as in Fig. 1)

9.4°). This angle was large in the anterior dislocation group (41.5±17.7°) (Fig. 1).

The upper deviation of the head center did not differ significantly between the dislocation-free group (0.42± 0.58) and the posterior dislocation group (0.36±0.09). This parameter in the anterior dislocation group (0.38±0.11) was also close to that in the other two groups. The outer deviation of the head center did not differ significantly between the dislocation-free group (0.49±0.14) and the posterior dislocation group (0.52±0.10). This parameter was slightly lower in the anterior dislocation group (0.38± 0.07). The upper deviation of the tip of the greater trochanter did not differ significantly between the dislocation-free group (0.36±0.18) and the posterior dislocation group (0.43±0.31). This parameter in the anterior dislocation group (0.38±0.14) was close to that in the other two groups. The outer deviation of the tip of the greater trochanter did not differ significantly between the dislocation-free group (1.31±0.76) and the posterior dislocation group (1.31±0.26). This parameter in the anterior dislocation group (1.24±0.09) was close to that in the other two groups (Fig. 2).

Discussion

The incidence of dislocation following total hip arthroplasty varies among reports, but it has most often been stated as 3–4% [3, 5, 8, 9]. The incidence in the present study was also in this range. Of the ten hips that dislocated, eight occured within 3 months after the operation. Therefore, the period until the surrounding soft tissues are repaired completely and the pseudo-capsule of the joint is formed to an adequate extent after surgery may be deemed as the period for increased risk of dislocation. In the present study, recurrent dislocation was seen in only three hips. This suggests the importance of patient awareness and education about dislocation. In the classification of dislocation proposed by Dorr [1], by which dislocation is etiologically categorized as positional (type 1), soft tissue imbalance (type 2) and component malposition (type 3), four of our cases were type 1 and six were type 3. No definite type 2 case was determined. However, since multiple factors appeared to be involved in the etiology of the dislocation observed in some cases, it would seem difficult to simply divide the dislocation into three types. Regarding the angles of the hip prosthesis, Lewinnek et al. [4] proposed the safe zone as 30–50° for the inclination angle of the cup and 5–25° for the anteversion angle of the cup. In this study, however, these angles in four of the ten dislocated hips were within these zones. Therefore, the safe zones proposed by Lewinnek et al. may not be valid under all circumstances (Fig. 3).

Kadakia et al. [2] performed total hip arthroplasty on cadavers and examined the angle of hip joint flexion at varying anteversion angles and a constant inclination angle (40°) of the cup, as well as the angle of adduction causing impingement and dislocation. They reported that when the angle of flexion was 105°, a change in the anteversion angle of the cup from neutral to 15° anteversion resulted in an increase of the minimal adduction angle causing impingement from 20.9° to 31.6° and dislocation from 29.9° to 43.8°. They also reported that when the adduction angle was 20°, the minimal angle of flexion causing dislocation increased from 93° to 115° as the anteversion angle of the cup was changed from 15° retroversion to neutral. Thus, the anteversion angle of the cup was a factor influencing the occurrence of dislocation.

Also in our study, only the anteversion angle of the cup differed significantly between the dislocation group and the dislocation-free group, and no other setting angles differed significantly between these two groups. Therefore, the anteversion angle of the cup must be viewed as an important factor.

When the relationship between the anteversion angle of the cup and the antetorsion angle of the stem was analyzed, the incidence of posterior dislocation was seen to increase as the two angles became smaller, and that of anterior dislocation increased as the two angles became larger (Fig. 4). In our study, no dislocation was seen when the sum of the anteversion angle of the cup and the antetorsion angle of the stem was between 45° and 65°, irrespective of the magnitude of the inclination angle of the cup. As the sum increased beyond this range, anterior dislocation tended to occur. As the sum decreased below this range, posterior dislocation tended to develop (Fig. 5). These results suggest that the anteversion angle of the cup is the most important factor determining the development of postoperative dislocation of the hip joint, and the safe zone of this angle seems to be between 20° and 30°. This safe zone may be expanded by the additive effect of antetorsion angle of the stem.

Like Kadakia et al. [2], Sahni et al. [6] also analyzed cup anteversion in relation to the adduction and flexion angles in a study of total hip arthroplasty in cadavers. They reported that 44% of all dislocations were caused by impingement of the stem with the acetabular line, 22% were caused by bony femur impingement on the pelvis, and 33% were independent of any impingement.

Therefore, when setting a hip prosthesis, the anteversion angle of the cup is the most important factor to be taken into consideration, but it is also essential to adjust the antetorsion angle of the stem to match the shape of individual bones to create a more stable hip joint. Finally, the tension in the soft tissues, should also be borne in mind to avoid postoperative dislocation after total hip arthroplasty.

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