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Causes of and Treatment Protocol for Instability of Total Hip Replacement

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Dislocation of the total hip replacement is a devastating complication, physically and mentally. It was determined whether there are radiographic or operative findings predictive of repeat dislocation and whether there are causes of dislocation that require immediate reoperation. A previously published classification of dislocations was used which evaluates (1) positional (no radiographic abnormality); (2) component malposition (femur or acetabulum), which is inadequate version or position of the acetabular or femoral component; (3) soft tissue imbalance (change in the length or displacement of the hip), which is a change in the muscle functional length of the hip; and (4) component malposition and soft tissue imbalance. Categories of treatment of dislocations were established that could be correlated to the cause of the dislocation: (1) Category I is a successful closed reduction; (2) Category II is a successful reoperation; (3) Category III is a reoperation with subsequent repeat dislocations successfully treated with closed reduction; and (4) Category IV is comprised of hips that require multiple reoperations for treatment of dislocations. The results are that any dislocation of any origin may be treated successfully with closed reduction so that this should be the first choice of treatment. To avoid multiple treatments, immediate reoperation should be performed if the hip is unstable when the patient is examined under anesthesia after the closed reduction. Hips with soft tissue imbalance and weakness of the abductor musculature, with or without component malposition, are most at risk for multiple operations. These hips may be considered for mechanical stability (constraint in the acetabular replacement) at reoperation.

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Dislocation is the second most common major complication of total hip replacement.[6,13,16] Technical errors and imbalance of tissues around the hip, as can be measured on radiographs, have been implicated by many authors.[5,6,10,14,15] Component malposition, particularly of the socket, was described by Ritter,[17] Carlsson and Gentz,[1] Dorr et al,[5] and McCollum and Gray.[13] Soft tissue imbalance, particularly with nonunion of the trochanter, was described by Woo and Morrey,[18] Lindberg et al,[12] and Dorr et al.[5] Some patients have dislocation of the hip replacement with no identifiable reason for the dislocation shown on the radiograph. This was named positional dislocation by Dorr et al.[5] Most probably the cause for dislocation in these patients is impingement of the metal femoral neck against the edge of the acetabular component[2,8,9] or of the femoral bone and intervening soft tissue against the pelvis.

The primary reason for a study of dislocation is to identify factors for prevention and treatment. The purpose of this study was to determine the correlation between the cause of dislocation and the treatment used for dislocation. Questions that need to be answered include: Are certain radiographic findings predictive of repeat dislocations; should dislocation of some origins require immediate reoperation; and when should mechanical stability be used as treatment for dislocation?

MATERIALS AND METHODS

Between October 1992 and January 1997, 71 patients with 72 hips were treated for dislocation of the total hip replacement. Forty-three (60%) were women and 28 were men. The average age of the patients was 61 years (range, 25–81 years) and the average weight was 163 pounds (range, 103–351 pounds). The dislocation of the hip occurred in 37 (51%) of these hips after primary total hip replacement, and in 35 (49%) the dislocation occurred after revision hip surgery. Thirteen of the hips with primary surgery had had prior hip surgery and these hips, combined with the 35 revised hips, give a total of 48 (67%) hips that had had prior hip surgery. The time from the first dislocation after surgery (primary or revision total hip replacement) is recorded in Table 1. Twenty-two percent of the dislocations occurred within 1 month and 54% occurred less than 3 months. Fifteen percent of the dislocations occurred after 2 years postoperatively. Fourteen hips in 14 patients had the primary (index) surgery and 25 hips in 25 patients had the revision surgery which resulted in subsequent treatment of dislocation at the authors' institution. The remaining patients in this series were treated after referral to the authors' institution.

TABLE 1. The Time From Total Hip Replacement to First Dislocation

Time (months)	Hips
<1	16
1–3	23
3–6	7
6–9	11
12–24	4
>24	11
Total	72

Thirty-nine (54%) occurred in the first 3 months and 15% occurred after 2 years.

This study is not one of clinical satisfaction of the patient or of a specific treatment, so hip scores are not of value. However, the clinical evaluation of hip muscle strength is relative to the treatment protocol. Clinically, these patients had the strength of their hip musculature tested using a side lying abduction test. In this test, the patient lies in the lateral decubitus position with the affected hip up. The leg is held so that the femur is in a neutral position (no extension or flexion), which means that a straight line can be drawn along the axis of the body and specifically between the anterosuperior spine and the superior pole of the patella. The knee is flexed between 0° and 10° flexion. The patient then lifts the leg toward the ceiling. The leg should be maintained in the neutral position (and not flexed) as it is lifted upward. This maneuver requires strong hip abduction musculature (the gluteus medius and the upper head of the gluteus maximus muscle). If the patient cannot lift the leg (poor muscle grade), or if the patient cannot hold the leg in the lifted position against resistance (fair muscle grade), this is a positive side lying abduction test which means that the abductor musculature is weak. If the patient can hold the leg against resistance, and particularly if this is held strongly against resistance, the side lying abduction test is negative and the hip musculature is considered of adequate strength. The patients are classified into two groups: those with weak musculature of poor or fair grade, and those of strong musculature with good or better grade.

A standardized radiographic protocol was used for all patients which included a supine anteroposterior (AP) radiograph of the pelvis to include both hips and proximal femur and a modified Lowenstein or Cleave lateral projection of the hip.[4] Radiographic measurements were performed by the author (ZW) who did not treat the patients. Measurements were made on the radiographs of the primary or revised total hip replacement that had been taken before the dislocation. For measurements, the opposite hip was used as a comparison (Fig 1). When the opposite hip was not able to provide accurate measurement controls, such as the presence of a revision hip replacement with bone defects, or developmental dysplasia, the preoperative radiograph of the surgically treated hip (when available) was used as the measurement control. Radiographs were measured for the hip length,

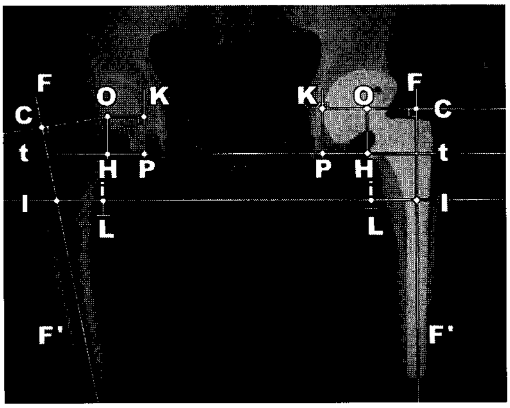


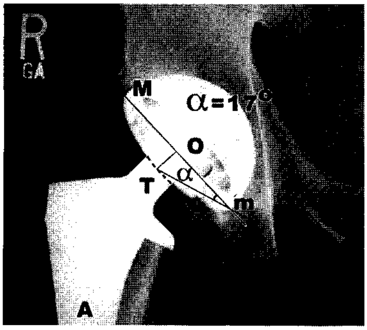
Fig 1. Radiograph showing measurements made: t-t prime is reference line between tear drops. F-F prime is reference line that is the axis of the femur. II is reference line between the ischial tuberosities. K-P is reference line constructed perpendicular to line t-t prime and represents the medial acetabular wall. Point K is placed on this perpendicular line at the level of the center of the head of the normal hip. H-O is the line that measures the height of the center of femoral head from line t-t prime. O-O is the center of the femoral head. O-C is femoral offset. K-O plus O-C is femoral displacement. iL is the line that measures the hip length by the distance from line II to the apex of the lesser trochanter (point L).

hip offset, femoral displacement, vertical and horizontal center of head displacement, cup abduction angle, and shortening of the gluteus medius muscle length (Fig 1). Radiographic measurements were considered abnormal if the measurement was 10 mm or more, either greater than or less than, from the normal position.[5]

The method used for measuring anteversion or retroversion of the acetabular component is a modification of the method described by Hassan et al[7] and is a combination of the measurements of the AP radiograph of the pelvis and the AP radiograph of the hip (Fig 2). An AP radiograph of the pelvis and an AP radiograph of the hip were available for 44 hips, with 24 hips having only an AP radiograph of the pelvis. The measurement of the version of the acetabular components was done in 68 hips. Four hips were excluded because one hip had a metal on metal replacement and three hips had cemented rings, and measurements in these hips could not be performed accurately because of the amount of metal which overlaid the cup. Operating reports on those hips reoperated on were used to verify radiographic measurements. The method of measurement is shown in Figure 2. The inferior margin of the acetabular component usually is hidden by a metal head and this necessitates drawing the extended curve of the inferior margin of the acetabular component. Anteversion is present when the alpha angle of the AP radiograph of the hip is greater than that of the AP radiograph of the pelvis and retroversion is present when the alpha angle of the AP radiograph of the hip is less than that of the AP radiograph of the pelvis. The difference of the alpha angle between the AP radiograph of the pelvis and AP radiograph of the hip is 4° to 5°. Therefore, the true anteversion of the acetabular component is the angle measured on the AP radiograph of the pelvis, plus 5°. The true retroversion is the angle measured on the AP radiograph of the pelvis, minus 5°. In 24 hips without AP radiograph of the hip, the version can be determined from the AP radiograph of the pelvis by the method of Lewinnek et al[11] and anteversion confirmed from the operative report. Anteversion less than 15° or more than 30° and a theta (abduction) angle of 55° or more are considered malposition.[5]

Radiographic measurements and operative reports were used to classify the hip into one of four causes of dislocation:[5] (1) A positional dislocation always has correct component position and soft tissue balance as measured on the radiograph; (2) component malposition has femoral and/or acetabular malposition; (3) soft tissue imbalance of the hip, that is, shortening of muscles and fascia, is diagnosed using radiographs by identifying nonunion of the trochanter, shortening of the hip by the relationship of the lesser trochanter to the ischium, or increased or decreased femoral displacement (Fig 1). Femoral offset was less accurate than femoral displacement in measuring the position of the femur to the pelvis. The femoral offset measures the offset of the implant used and did not necessarily reflect the position of the femur to the pelvis. For example, if the cup is lateralized, the femoral bone is displaced laterally, but the offset remains the same as the femoral stem used; and (4) a combination of component malposition and soft tissue imbalance.

The treatment of dislocation of total hip replacement includes the option of closed reduction or reoperation with open reduction with or with-



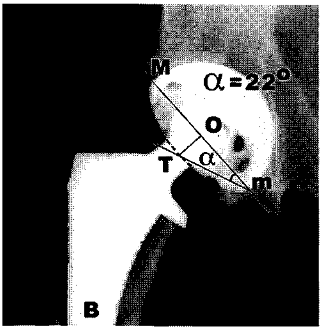


Fig 2. (A) On the AP radiograph of the pelvis, the line Mm is drawn with O being placed at the center of line Mm. The line OT is perpendicular to the line Mm. The inferior margin of the acetabular component is hidden partially by the metal head. An extended curve is drawn along the inferior margin of the acetabular component which completes the inferior margin. The point at which the line OT contacts the inferior margin of the acetabular component is connected to point M. The alpha angle then can be measured and in this example is 17°. (B) On an AP radiograph of the hip, the same measurement is done. The alpha angle of this hip is 22° which means the acetabular component is in anteversion.

out revision. According to the treatment choice, dislocations of the hip replacement can be categorized into four groups. Category I includes dislocations that were treated by a closed reduction and no additional treatment was needed. These patients may have more than one closed reduction, but do not require operative treatment. Category II includes dislocations that were treated unsuccessfully by closed reduction and required reoperation. After the reoperation no additional dislocations occurred. Category III includes dislocations that were treated unsuccessfully by closed reduction and then had revision surgery, but had additional dislocation of the hip after revision that was treated successfully by closed reduction. The sequence of treatment for these hips, therefore, is closed reduction followed by revision, followed by successful closed reduction. Category IV includes dislocations that had failed closed reduction, had revision, then had recurrent dislocations that required another revision. Category IV includes dislocations that require at least two operations for treatment.

All data were analyzed statistically using SPSS software (SPSS Inc, Chicago, IL). The chi square test was used in all statistical analyses.

RESULTS

Clinical examination of the musculature showed that weakness of the abductor musculature is prevalent in hips with dislocation. Seven of 17 hips in Category I had a positive side lying abduction test; 12 of 23 hips in Category II had a positive side lying abduction test; four of eight hips in Category III had a positive side lying abduction test; and 22 of 24 hips in Category IV had a positive side lying abduction test. Weakness of the abductor musculature (muscle graded fair or less) is predominant in hips that have multiple operations for treatment of dislocation.

Sixty-eight of 72 hips did have completion of the hip measurements. The measurement results for anteversion are listed in Table 1. One hip had retroversion of 5° (confirmed by the surgeon's operation report). Sixty-seven hips had anteversion with two hips between 1° and 4°, eight between 5° and 9°, and 14 be-

TABLE 2. Version of the Acetabulum

Version	Angle (°)	Number of Hips
Anteversion	0–4	2
	5–9	8
	10–14	14
	15–20	17
	21–25	17
	26–30	9
Retroversion	1–5	1
Total		68

Anteversion of less than 15° or more than 30° and any retroversion is considered malposition of the acetabulum. There were no hips with anteversion greater than 30°. Twenty-four (35%) hips had anteversion less than 15°.

tween 10° and 14°. No hip had more than 30° anteversion (Table 2). Twenty-five hips that had 0° to 14° anteversion were considered to have inadequate anteversion. Abduction of 55° or more was recorded in six hips. Four hips had abduction between 55° and 59° and two hips had abduction between 60° and 64°.

Fourteen hips had component malposition alone. Ten hips had anteversion of the acetabulum less than 15°, three hips had abduction of the acetabulum of 55° or greater, and one hip had retroversion of the femoral stem.

Twenty-nine hips had soft tissue imbalance. Trochanteric nonunion was present in 12 hips, either alone or in combination with other abnormalities, and was the most common cause of dislocation in those hips that had soft tissue imbalance. Twelve hips had femoral displacement with seven being reduced by 1 to 4 cm and five increased by 1 to 3 cm. Thirteen hips had offset changes, with seven showing a reduced offset and six showing an increased offset. Nine hips had hip length changes with one hip being shorter and eight being longer. Most hips had a combination of these changes.

Combined soft tissue imbalance and component malposition was present in 18 hips. Component malposition was anteversion of the cup less than 15° in 15 hips, and three of these also had abduction of more than 55°. Three hips had retroversion of the femoral component and one also had anteversion less than 15°. Soft tissue imbalance always was present and five hips had nonunion of the greater trochanter. Ten had a change in femoral displacement with five reduced 1 to 3 cm, and five increased 1 to 3 cm. Twelve hips had femoral offset changes with five reduced 1 to 3 cm, and seven increased 1 to 3 cm. Hip length was 1 to 3 cm shorter in five hips, and 1 to 3 cm longer in five hips.

Closed reduction as an initial treatment was successful in some patients in each classification of cause of the dislocation, but those with any soft tissue imbalance as the cause of dislocation required reoperation at least 80% of the time. Eleven hips were classified as positional, which means no radiographic measurements were abnormal, yet only five of 11 were treated successfully by closed reduction alone. It is significant that all five of these patients had normal clinical testing of the abductor musculature. Fourteen hips had measurable component malposition as the single cause of dislocation and 71.4% of these hips required reoperation. Twenty-nine hips had soft tissue imbalance as the singular cause of dislocation and 82.8% of these hips required reoperation. Eighteen hips had a combination of component malposition and soft tissue imbalance and 83.3% of these hips required reoperation. The number of hips in each category of treatment is presented in Table 3. There is no statistical difference between categories for the necessity of surgical treatment, but there are clear clinical differences with the pres-

TABLE 3. The Relationship of Causes of Dislocation and Categories of Treatment

Cause	Category *I*	*II*	*III*	*IV*	Total
Positional	5	4	1	1	11
Component malposition	4	3	2	5	14
Soft tissue imbalance	5	9	4	11	29
Malposition and soft tissue imbalance	3	7	1	7	18
Total	17	23	8	24	72

Category I is closed reduction only, with 24% of the patients able to be treated with only closed reduction. Category IV is multiple operations for success and this represents 33% of the patients. The most common cause of dislocation is soft tissue imbalance. There is no statistical difference between the different treatments for any of these dislocations ($p = 0.613$).

ence of soft tissue imbalance causing the most risk for reoperation.

Forty-eight of 72 (67%) hips were treated successfully either with closed reduction or a single reoperation. These included hips in Category I with successful closed reduction (25% of hips), and hips in Categories II and III which represents successful singular operations for the treatment of dislocation (42% of hips). Hips in Category III subsequently did dislocate and were treated with closed reduction.

Twenty-four hips required more than one operation for treatment (Category IV). Only one of the hips in Category IV had a radiograph with no abnormal measurements. At the initial operation for this patient, impingement against the cup was discovered and the cup was changed. The patient's hip subsequently dislocated again after that operation and because of a severely weak gluteus medius muscle had a constrained cup placed at the second operation. The final successful operation in hips in Category IV included revision of the acetabular component in 17 of 22 hips with constraint used for 12 hips. The stem was revised with the cup in seven hips.

Constraint in the acetabulum was used in 24 hips with all having a diagnosis of soft tissue imbalance. Twelve hips had dislocation caused by soft tissue imbalance alone, and 12 hips had a diagnosis of combined malposition and soft tissue imbalance. Four of these 24 acetabular replacements were bipolar acetabular components and 20 of these were constrained acetabular cups (15, S-ROM [Johnson and Johnson, Braintree, MA] and five, Biomet [Biomet, Warsaw, IN]). In 11 hips the constraint was achieved by cementing the constrained liner into an acetabular cage or preexisting acetabular component. Five constrained inserts were cemented into an acetabular ring support and six into a well fixed metal acetabular component. The inner surface of the metal shell and the outer surface of the polyethylene constrained insert were roughened with a high speed drill to enhance cement fixation.

A constrained cup or bipolar cup was a successful treatment for prevention of dislocation. Five of 24 constrained cups had a postoperative dislocation, but with nonconstrained cups used in these hips, dislocation recurred in 48 of 71 operations (24 patients had multiple operations), ($p = 0.000$). No constrained cup failed by loosening, but in one cup into which the polyethylene insert had been cemented the insert disassembled. The size of the insert for this cup had been too large and the insert did not seat into the metal shell. Four of five failures of the constrained cups occurred in hips with component malposition and soft tissue imbalance and correction was achieved by acetabular revision in three and by closed reduction in one. The fifth failure was salvaged by use of a longer modular femoral head because the hip length was too short.

A pantaloon cast[5] was used 59 times (more than once in some hips) for 6 weeks after closed reduction or operative treatment. After the use of a cast, no additional dislocation occurred in 18 patients, but additional dislocation occurred in 41 of the 59 patients. The ratio of success to failure with a cast was 1:23. In 17 hips with successful closed reduction, five were treated with a cast, 10 with a hip brace, and two had no support.

DISCUSSION

Dislocations are destructive physically. As many as two of three are recurrent and require reoperation.[5] In the current series, one of three hips that dislocated required more than one operation. This is similar to the data of Woo and Morrey[18] who reported 31% recurrent instability after surgery for dislocation. One of the major tissues damaged with recurrent dislocation is the abductor mechanism. This previously has been shown with gait analysis.[3] In the patients in the current series, 22 of 24 hips with multiple operations for dislocation (Category IV) had a weak abductor mechanism when tested clinically.

Dislocations are destructive mentally. Patients avoid social activities and become depressed. Dislocations should be treated aggressively. The treatment for the dislocation must be surgical for patients with recurrent dislocations. In an earlier report on dislocations, surgical treatment was recommended after a second dislocation and this continues to be a good rule for treatment.[5] Each of the four categories of causes of dislocation described did have some hips successfully treated by closed reduction (Category I), which suggests that each dislocated hip should be treated initially by closed reduction. If a hip is grossly unstable at the time of closed reduction, then surgical treatment should be done immediately. Because of the high rate of operative treatment and recurrence of dislocation, the authors now place all hips in a pantaloon cast or a hip brace for 6 weeks after the initial closed reduction. Despite the fact that the failure rate for the use of a cast in this series is higher than the success rate, the authors still advocate the use of a brace or a cast because it is successful in some hips. This is an example of clinical significance sometimes being more important than statistical significance. The use of the cast is done because the gluteus medius will be weakened by dislocation[3] and the cast gives the best chance for fluid in the hip to resorb and a soft tissue scar to form around the hip cavity.

Patients should be operated on after a second hip dislocation. With dislocations there often is absent capsular regeneration and a smooth cystic lining is found to cover the trochanter and gluteus maximus muscle. The smooth lining must be removed to permit scar formation to seal the hip. With component malposition it is critical to correct both components if both are incorrect. Two hips in this study required two operations because both components were incorrect and only one was changed at the first operation. A well fixed femoral component is difficult to remove, but this must be done if it has an incorrect version. The use of a constrained cup to compensate for malposition of a component is not effective. In this study, four of five hips that had recurrent dislocation after insertion of a constrained cup had component malposition that was not corrected.

Mechanical stability for the hip can be effective for treatment of dislocation. The indications for the use of a constrained cup or bipolar cup are when soft tissue imbalance or combined soft tissue imbalance and component position are the cause of dislocation. If any component malposition is present this must be corrected also. Acetabular constraint (20 cups and four bipolars) were used to provide mechanical protection against poor soft tissue strength of muscle and scar in 12 of 24 hips with soft tissue imbalance and 12 of 18 hips with combined component malposition and soft tissue imbalance. Twelve of 24 (50%) of these constrained acetabular components were used in patients in Category IV. In this series no patient with component malposition as the singular cause of dislocation required treatment with a constrained cup. The most common reason for hips with component malposition becoming Category IV was failure to correct the component malposition at the initial revision surgery.

Hips with soft tissue imbalance are most likely to require reoperation. Closed reduction was most successful when no radiographic evidence of abnormality could be measured (positional cause of dislocation). Closed reduction was successful in only four of 14 hips with component malposition, five of 29 with soft tissue imbalance, and three of 18 with component malposition and soft tissue imbalance. A hip that dislocates because of component malposition has a 71.4% chance to require surgery and a 35.7% chance to be in Category IV; a hip that dislocates because of soft tissue imbalance has a 82.8% chance to require surgery and a 37.8% chance to be in Category IV; and a hip that dislocates because of combined component malposition and soft tissue imbalance has a 83.3% chance to require surgery and a 38.9% chance to be in Category IV.

Failure of operative treatment for dislocation is high when muscle weakness is present. Muscle weakness of the abductor mechanism (gluteus medius and upper gluteus maximus) as measured clinically by the side lying abduction test is present in 90% of hips with two or more operations for dislocation (Category IV). This test is important to perform when making treatment decisions for recurrent dislocations. If a patient with recurrent dislocation has musculature this weak, in combination with the radiographic findings of soft tissue imbalance, then consideration of a constrained cup is necessary. The potential for earlier loosening and failure of the constrained cup must be weighed against the mentally crippling effect to the patient of the failure of treatment.

The classification of cause of a dislocation by using radiographs will allow a prediction of the risk of recurrent dislocations. Immediate reoperation should be considered for patients with soft tissue imbalance or component malposition and soft tissue imbalance as the cause of the dislocation of their hip, particularly if the hip is unstable at the time of attempted closed reduction. With any reoperation, component malposition must be corrected and if the hip has poor muscle control and absent capsular tissue, mechanical constraint for the acetabulum should be used.

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