The Prognosis in Untreated Dysplasia of the Hip

A Study of Radiographic Factors That Predict the Outcome*

BY STEPHEN B. MURPHY, M.D.†, REINHOLD GANZ, M.D.‡, AND MAURICE E. MÜLLER, M.D.§, BERN, SWITZERLAND

Investigation performed at the Maurice E. Müller Foundation for Continuing Education in Orthopaedic Surgery, Bern

ABSTRACT: To help to determine the natural history of residual dysplasia of the hip after skeletal maturity, we followed the status of the contralateral hip in 286 patients who had had a total hip replacement for osteoarthrosis secondary to dysplasia. The initial radiographic findings in seventy-four patients in whom advanced osteoarthrosis later developed in the contralateral hip were compared with those in forty-three patients who had reached the age of sixty-five years without having had severe osteoarthrosis.

No patient in whom the hip functioned well until the age of sixty-five years had had a center-edge angle of less than 16 degrees, an acetabular index of depth to width of less than 38 per cent, an acetabular index of the weight-bearing zone of more than 15 degrees, uncovering of the femoral head of more than 31 per cent, or an acetabulum in which the most proximal point of the dome had been at the lateral edge (zero peak-to-edge distance).

The operative treatment of residual dysplasia of the hip after skeletal maturity is based on the assumption that the dysplasia, if left untreated, will lead to secondary osteoarthrosis of the hip[2,3,9,10,12,13,16-18]. Although the natural history of dysplasia of the hip has not, to our knowledge, been fully defined, this assumption is commonly accepted because of countless examples of osteoarthrosis in dysplastic hips that have not been treated. It is further supported by numerous studies that have demonstrated that dysplasia of the hip is a major cause of osteoarthrosis[5,12,14,15].

While it has been clearly demonstrated that untreated severe dysplasia of the hip frequently leads to osteoarthrosis[1,4,16,19-22], we are not aware of reports on how often osteoarthrosis develops in hips in which the dysplasia is less severe. Although there is no debate that severe dysplasia of the hip should be treated operatively, objective criteria on which to base the treatment of mild or moderate dysplasia are not available. This study was undertaken to establish such criteria.

Materials and Methods

All of the patients in this study were managed by the senior one of us (M. E. M.) at the Insel and Lindenhof Hospitals in Bern, Switzerland, from October 1965 through April 1990. Two hundred and eighty-six patients who had had a total hip replacement for osteoarthrosis that was clearly secondary to dysplasia of the hip were followed for the development of osteoarthrosis in the contralateral hip. The severity of the osteoarthrosis was graded with use of the classification system of Kellgren and Lawrence, according to which a grade of 0, 1, or 2 indicates no more than slight loss of the thickness of the articular cartilage, slight formation of osteophytes, and no formation of subchondral cysts, while a grade of 3 or 4 signifies substantial or complete loss of the thickness of the articular cartilage or substantial formation of osteophytes. Of the 286 patients, 115 eventually had severe (grade-3 or 4) osteoarthrosis in the contralateral hip (group I), forty-six survived to an age of

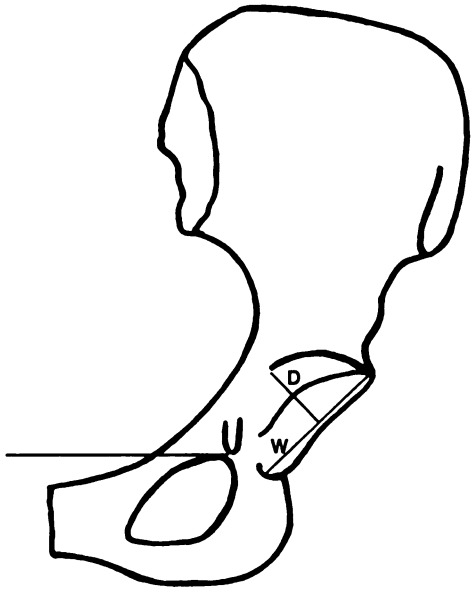

FIG. 1

The acetabular index of depth to width (D/W).

*No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. Funds were received in total or partial support of the research or clinical study presented in this article. The funding source was the Maurice E. Müller Foundation for Continuing Education in Orthopaedic Surgery.

†Department of Orthopaedic Surgery, Beth Israel Hospital, 330 Brookline Avenue, Boston, Massachusetts 02215.

‡Department of Orthopaedic Surgery, University of Bern, Inselspital, CH-3010 Bern, Switzerland.

§Foundation Maurice E. Müller, Murtenstrasse 35, Postfach 7560, CH-3001 Bern, Switzerland.

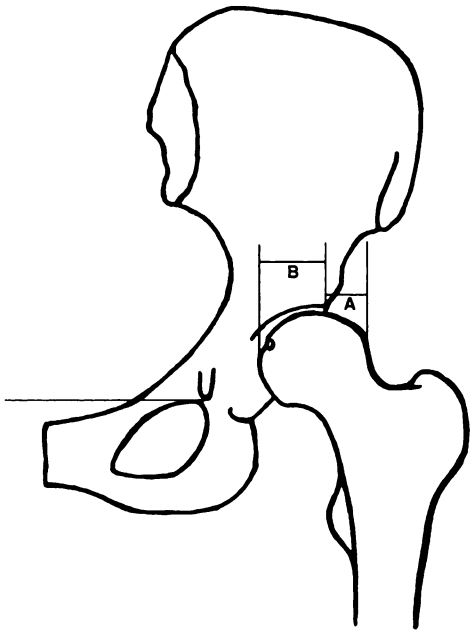

FIG. 2

The femoral-head extrusion index is a percentage that is calculated by dividing the horizontal distance of the part of the femoral head that is lateral to the edge of the acetabulum (A) by the total horizontal width of the femoral head (A + B) and multiplying by 100: (A/[A + B]) × 100.

sixty-five years with no or less-than-severe (grade-0, 1, or 2) osteoarthrosis developing in the contralateral hip (group II), and the remaining 125 patients did not have severe osteoarthrosis but were still less than sixty-five years old at the latest follow-up visit.

Because it was the only radiograph that had been made for all patients, an anteroposterior radiograph of the pelvis was used for this study. Radiographic parameters were compared for groups I and II to determine which parameters were associated with the development of osteoarthrosis. The parameters that were measured included the center-edge angle of Wiberg, the acetabular index of depth to width described by Heyman and Herndon (Fig. 1), the femoral-head extrusion index[6] (Fig. 2), and the acetabular index of the weight-bearing zone[16] (Fig. 3). In addition, we quantified lateral subluxation by measuring from the lateral side of the teardrop to the medial edge of the femoral head (Fig. 4). Superior subluxation was quantified by measuring vertically from the inferior edge of the acetabulum to the inferior margin of the femoral head (Fig. 5). Finally, we measured the distance from the apex of the acetabular weight-bearing dome to the lateral edge of the acetabulum (the peak-to-edge distance) (Fig. 6).

The earliest available radiograph was used for each patient. The diameter of the prosthetic head in the contralateral hip was used to correct for magnification. If the prosthesis had not been inserted by the time that the earliest radiograph was made, magnification was corrected by comparing the interteardrop distance on this radiograph with the interteardrop distance and the diameter of the prosthetic head on a subsequent radiograph.

The radiographic measurements were not made for forty-one of the 115 patients in group I because the hip was completely dislocated (twenty-one patients), because a femoral valgus osteotomy had been performed as a salvage procedure before the earliest radiographs were made (eleven patients), because the osteoarthrosis was too severe to allow measurement (six patients), because the hip had fused spontaneously (two patients), or because the pertinent radiographs could not be lo-

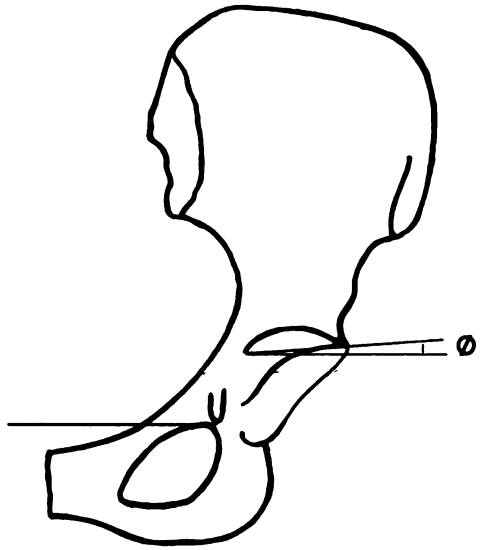

FIG. 3

The acetabular index (ø) is the angle formed between a line parallel to the weight-bearing dome (sourcil) and a line parallel to the interteardrop line.

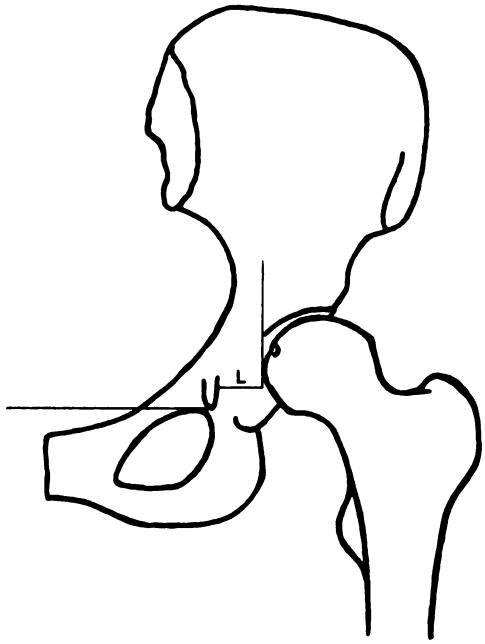

FIG. 4

Lateral subluxation (L) is measured from the lateral edge of the teardrop to the most medial portion of the femoral head.

cated (one patient). Of the seventy-four patients in group I for whom radiographic measurements were made, sixty-seven eventually had a total hip replacement and seven had end-stage osteoarthrosis that was not treated operatively because of other medical reasons.

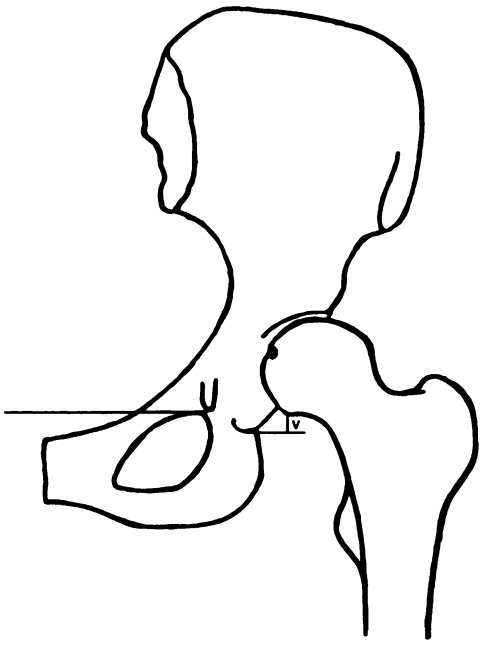

FIG. 5

Superior (vertical) subluxation (V) is measured vertically from the most inferior portion of the ischial part of the acetabulum to the most inferior portion of the femoral head.

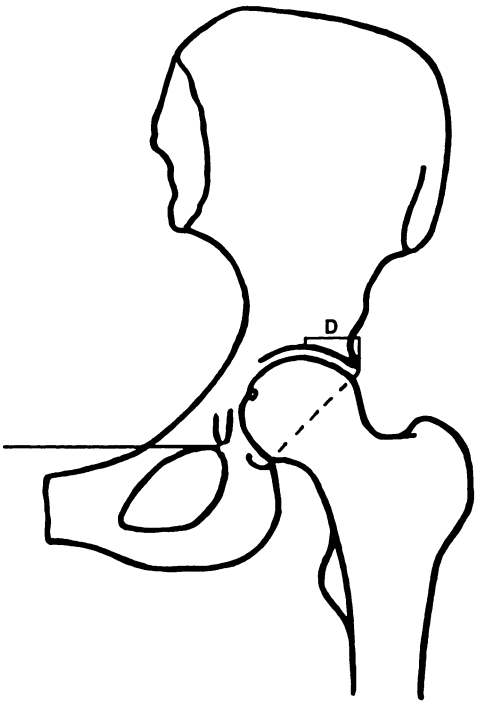

FIG. 6

Peak-to-edge distance (D). A horizontal line parallel to the inter-teardrop line is drawn across the apex of the acetabulum (the most proximal point of the dome). The horizontal distance from the apex to the acetabular edge is then measured.

Of the forty-six patients in group II, three had records that could not be located, leaving forty-three patients for the analysis.

No patient was excluded from the study because he or she had had closed treatment or open reduction as a child. Two patients in group I had had a varus femoral osteotomy, and osteoarthrosis had developed subsequently. No patient in group II had had a previous reconstructive femoral or pelvic osteotomy.

The radiographic parameters for the two groups were compared with use of a two-tailed t test. Comparisons between groups I and II were made with use of a two-sample Student t test. Significance testing was two-sided. To adjust for multiple comparisons, an experimentwise significance level was set at 0.005.

Results

The two groups differed significantly ($p < 0.0001$) with respect to all seven radiographic parameters.

The center-edge angle[22] had been 7 ± 12 degrees (mean and standard deviation), with a range of −22 to 28 degrees, in the patients in whom osteoarthrosis had developed (group I) and 34 ± 9 degrees, with a range of 16 to 49 degrees, in the patients in whom osteoarthrosis had not developed (group II). Only two patients in group II had had a center-edge angle of less than 20 degrees.

The patients in whom osteoarthrosis had developed (group I) had had a mean vertical distance of 10 ± 8 millimeters (range, −2 to twenty-six millimeters), compared with 1 ± 2 millimeters (range, −8 to seven millimeters) in the patients in whom osteoarthrosis had not developed (group II).

The mean lateral distance (from the teardrop to the femoral head) had been 13 ± 4 millimeters (range, five to twenty-two millimeters) in group I and 6 ± 2 millimeters (range, three to eleven millimeters) in group II.

The peak-to-edge distance had been 3 ± 5 millimeters (range, zero to nineteen millimeters) in group I and 16 ± 4 millimeters (range, five to twenty-four millimeters) in group II.

The femoral-head extrusion index had been 36 ± 12 per cent (range, 15 to 62 per cent) in group I and 12 ± 8 per cent (range, 0 to 31 per cent) in group II.

The acetabular index of depth to width[6] had been 31 ± 7 per cent (range, 19 to 53 per cent) in group I and 48 ± 6 per cent (range, 38 to 62 per cent) in group II.

The acetabular index of the weight-bearing zone[16] had been 25 ± 10 degrees (range, 6 to 46 degrees) in group I and 6 ± 6 degrees (range, −5 to +15 degrees) in group II.

Discussion

Residual dysplasia of the hip in a patient who has reached skeletal maturity is often treated operatively in an effort to produce a stable hip that will last a life-

time[2,3,9,11,15,16]. This treatment is based on two assumptions: that dysplasia of the hip of a certain severity leads to osteoarthrosis, and that improvement in the mechanics of the joint will arrest the degenerative process. The choice of treatment for a young patient who has minor symptoms and moderate dysplasia is especially difficult, and there are few objective criteria to assist the surgeon in this decision.

It is very difficult to study the natural history of dysplasia of the hip because the natural history is altered by treatment. It is unlikely that a prospective randomized study of the natural history of untreated dysplasia of the hip will ever be conducted. Currently, symptomatic patients are generally managed with an osteotomy before the onset of degenerative osteoarthrosis.

The present study, in which we attempted to identify the radiographic parameters that predicted the outcome of untreated dysplasia, was limited by several factors that might have biased the outcome. The longevity of a hip contralateral to a severely dysplastic hip is probably altered. The contralateral hip may be excessively stressed to protect the more involved hip or, conversely, it may be protected because the dysplasia of the more involved hip limits the patient's activity. Because the extremity on the side of the less involved hip is usually relatively longer, increased adduction may cause the femoral head on that side to have less acetabular coverage. The eventual replacement of the more severely involved hip may also influence the outcome.

The current study was also limited because many of the hips in which secondary osteoarthrosis developed already had signs of osteoarthrosis on the earliest radiographs. Thus, the parameters for group I are, to some degree, measurements of secondary osteoarthrosis. Also, because data on the weights and the levels of activity of the patients in the two groups were not available, the possibility of confounding due to a difference in these factors between the two groups cannot be ruled out.

Conversely, the fact that no patient in group II had severe dysplasia as seen on the anteroposterior radiographs demonstrates quite clearly that, in patients who have had a replacement for dysplasia of one hip, severe osteoarthrosis will inevitably have developed in the contralateral hip in which there is severe dysplasia. This is a very important finding.

The anteroposterior radiograph of the pelvis was used in this study simply because it was available. An anteroposterior radiograph is a relatively insensitive tool for the diagnosis of dysplasia of the hip; a false-profile radiograph is much more sensitive for this diagnosis[8]. Patients who have had pain in the hip and a nearly normal anteroposterior radiograph have been found to have deficient anterior coverage or even anterior subluxation on the false-profile radiograph[3].

Given the constraints of the anteroposterior radiograph, the center-edge angle is a fairly sensitive indicator of dysplasia of the hip. This angle decreases as a result of three factors: acetabular dysplasia, which determines the lateral edge; coxa magna or coxa plana, which enlarges the radius and moves the center laterally; and lateral subluxation. The combination of these three factors drastically decreases the center-edge angle in the dysplastic hip as the disease progresses. The peak-to-edge distance is also a very useful indicator, as it is apparent that a hip in which the apex of the acetabulum is at the lateral edge will not last a lifetime. Although the radiographic values in the current study are clearly inconsistent with good long-term function of the hip joint, better values certainly do not guarantee that secondary osteoarthrosis will not occur.

Because dysfunction of the hip secondary to dysplasia is a complex problem that includes excessive stresses on the cartilage, dynamic instability, labral tears, muscular fatigue, and, frequently, eventual degenerative osteoarthrosis if left uncorrected, the application of our findings to the management of an individual patient must always be in the context of a full clinical and radiographic assessment.

Note: The authors thank Ms. Marbach and Ives Gerber of the Maurice E. Müller Foundation for Documentation for photographic assistance.

References

1. **Cooperman, D. R.; Wallensten, R.;** and **Stulberg, S. D.:** Acetabular dysplasia in the adult. *Clin. Orthop.*, 175: 79-85, 1983.
2. **Eppright, R. H.:** Dial osteotomy of the acetabulum in the treatment of dysplasia of the hip. In Proceedings of The American Academy of Orthopaedic Surgeons. *J. Bone and Joint Surg.*, 58-A: 726, July 1976.
3. **Ganz, R.; Klaue, K.; Vinh, T. S.;** and **Mast, J. W.:** A new periacetabular osteotomy for the treatment of hip dysplasias. Technique and preliminary results. *Clin. Orthop.*, 232: 26-36, 1988.
4. **Hadley, N. A.; Brown, T. D.;** and **Weinstein, S. L.:** The effects of contact pressure elevations and aseptic necrosis on the long-term outcome of congenital hip dislocation. *J. Orthop. Res.*, 8: 504-513, 1990.
5. **Harris, W. H.:** Etiology of osteoarthritis of the hip. *Clin. Orthop.*, 213: 20-33, 1986.
6. **Heyman, C. H.,** and **Herndon, C. H.:** Legg-Perthes disease. A method for the measurement of the roentgenographic result. *J. Bone and Joint Surg.*, 32-A: 767-778, Oct. 1950.
7. **Kellgren, J. H.,** and **Lawrence, J. S.:** Radiological assessment of osteoarthrosis. *Ann. Rheumat. Dis.*, 16: 494-502, 1957.
8. **Lequesne, M.,** and **de Seze, S.:** Le faux profil du bassin. Nouvelle incidence radiographique pour l'étude de la hanche. Son utilité dans les dysplasies et les différentes coxopathies. *Rev. rhumat.*, 28: 643-652, 1961.
9. **Millis, M. B.,** and **Murphy, S. B.:** Use of computed tomographic reconstruction in planning osteotomies of the hip. *Clin. Orthop.*, 274: 154-159, 1992.
10. **Müller, M. E.:** Intertrochanteric osteotomy: indication, preoperative planning, technique. In *The Intertrochanteric Osteotomy*, pp. 25-66. Edited by J. Schatzker. New York, Springer, 1984.

11. **Murphy, S. B.; Kijewski, P. K.; Millis, M. B.;** and **Harless, A.:** Acetabular dysplasia in the adolescent and young adult. *Clin. Orthop.*, 261: 214-223, 1990.
12. **Pauwels, F.:** *Biomechanics of the Normal and Diseased Hip. Theoretical Foundation, Technique and Results of Treatment. An Atlas,* pp. 136-143. Translated by R. J. Furlong and P. Maquet. New York, Springer, 1976.
13. **Salter, R. B.:** Innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. *J. Bone and Joint Surg.*, 43-B(3): 518-539, 1961.
14. **Stulberg, S. D.,** and **Harris, W. H.:** Acetabular dysplasia and development of osteoarthritis of the hip. In *The Hip. Proceedings of the Second Open Scientific Meeting of The Hip Society,* pp. 82-93. St. Louis, C. V. Mosby, 1974.
15. **Stulberg, S. D.; Cordell, L. D.; Harris, W. H.; Ramsey, P. L.;** and **MacEwen, G. D.:** Unrecognized childhood hip disease: a major cause of idiopathic osteoarthritis of the hip. In *The Hip. Proceedings of the Third Open Scientific Meeting of The Hip Society,* pp. 212-228. St. Louis, C. V. Mosby, 1975.
16. **Tönnis, D.:** *Congenital Dysplasia and Dislocation of the Hip in Children and Adults,* translated by T. C. Telger. New York, Springer, 1987.
17. **Wagner, H.:** Osteotomies for congenital hip dislocation. In *The Hip. Proceedings of the Fourth Open Scientific Meeting of The Hip Society,* pp. 45-66. St. Louis, C. V. Mosby, 1976.
18. **Wagner, H.:** Experiences with spherical acetabular osteotomy for the correction of the dysplastic acetabulum. *Prog. Orthop. Surg.*, 2: 131, 1978.
19. **Wedge, J. H.,** and **Wasylenko, M. J.:** The natural history of congenital dislocation of the hip: a critical review. *Clin. Orthop.*, 137: 154-162, 1978.
20. **Wedge, J. H.,** and **Wasylenko, M. J.:** The natural history of congenital disease of the hip. *J. Bone and Joint Surg.*, 61-B(3): 334-338, 1979.
21. **Weinstein, S. L.:** Natural history of congenital hip dislocation (CDH) and hip dysplasia. *Clin. Orthop.*, 225: 62-76, 1987.
22. **Wiberg, G.:** Studies on dysplastic acetabula and congenital subluxation of the hip joint. With special reference to the complication of osteo-arthritis. *Acta Chir. Scandinavica,* Supplementum 58, 1939.