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Innominate Osteotomy for the Treatment of Legg-Calvé-Perthes Disease

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A retrospective study was performed in 37 patients who underwent innominate osteotomy for the treatment of Legg-Calvé-Perthes disease. The majority of the patients (81%) were more than 6 years old, and the mean age was 7 years and 6 months. Thirty five hips were Catterall group III or IV, and 2 hips that had clinical and radiological "head at risk" signs were group II. The time interval between surgery and the final follow-up ranged from 2 to 6 years with a mean of 3 years and 10 months. Twenty five of 37 patients had good clinical results, and radiographs showed that the sphericity of the femoral head in the older age (>8 years) group was poorer, which demonstrated a similar pattern to the clinical results in this age group. We conclude that innominate osteotomy is a safe and effective procedure in severe Legg-Calvé-Perthes disease and this operation should be carefully selected as a treatment method in the appropriate age group.

Key Words: Innominate osteotomy, Legg-Calvé-Perthes disease

Legg-Calvé-Perthes disease (LCPD) is a self-limiting disease of the hip produced by ischemia and varying degrees of necrosis of the femoral head in children, but resultant deformity of the healed femoral head is the major factor in predisposition to the development of osteoarthritis of the hip joint (Salter and Bell, 1968; Axer and Schiller, 1972; Kamhi and MacEwen, 1972). Many different forms of treatment including conservative and operative interventions have been suggested to prevent femoral head deformity.

The femoral head deformity that develops in LCPD is believed to occur during the fragmentation phase of the disease (Gower and Johnston, 1971; Sommerville, 1971; Dickens and Menelaus, 1978; Glimcher, 1979). Many investigators have claimed that once the healing phase begins, further head deformation will not occur. This concept has formed part of the rationale for containment treatment. Currently, this principle of femoral head containment is based on the concept that the capital femoral epiphysis is vulnerable to deformity during the fragmentation phase of LCPD and that a good outcome depends on maintaining femoral head sphericity by containment within the acetabulum during this phase (Katz, 1968; Ingman *et al.* 1982; Lloyd-Roberts, 1982).

Surgical containment may be accomplished by femoral varus derotational osteotomy, innominate osteotomy, or a combination of the two. Containment may be improved operatively either by redirecting the neck of the femur or by repositioning the acetabulum. In 1966, when Salter described his theory of biological plasticity, he also reported innominate osteotomy in the treatment of LCPD (Salter, 1966; Salter, 1984). Additionally, a number of publications have appeared in which the results of innominate osteotomy for the treatment of LCPD are reported (Canale *et al.* 1972; Barer,

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1978; Park *et al.* 1979; Maxted and Jackson, 1985). The results were favorable in many of the studies, but less satisfactory in others. But we think that the disparity of the results are of limited value because of the heterogeneity of the patient populations (i.e. different age group and severity of the disease) in the different studies and the unpredictable, variable course of the disease.

In this study, we assessed the results of innominate osteotomy for the treatment of LCPD performed at our institution. And for comparison, we selected several reports of the results of treatment which have patient selection and classfication of outcomes similar to our series (Ingman *et al.* 1982; Robinson *et al.* 1988; Sponseller *et al.* 1988; Paterson *et al.* 1991).

MATERIALS AND METHODS

We reviewed the medical records and radiographs of the patients who had had an innominate osteotomy for the treatment of LCPD at the Severance Hospital, Yonsei University College of Medicine, Seoul, Korea.

We included in this study only patients for whom: ① the operation had been done between 1976 and 1992; ② no previous operation was undergone for treatment; ③ there was a minimum follow-up (F/U) of two years; and ④ radiographs were available.

Thirty seven patients met these criteria. There were 29 male and 8 female patients and none of the patients with bilateral involvement required surgery. The majority of the patients (81%) were more than 6 years old, and the mean age was 7 years and 6 months (Table 1).

The length of time between innominate osteotomy and the final assessment of each patient ranged from a minimum of 2 years to a maximum of 6 years, with a mean of 3 years and 10 months.

Anteroposterior and frog-leg lateral radiographs of the hips in the early fragmentation phase were classified by the Catterall classification. In order to be considered for surgery, patients had to have radiographic evidence of severe LCPD, of which 35 cases were in Catterall groups III or IV. Two cases of patients who were older than 8 years and had clinical and radiological "head at risk" signs were in group II (Table 2).

In addition, patients had to have a near normal range of hip motion immediately prior to surgery by skin traction and physio-therapy, or at the time of operation by release of contracted muscles around the hip. In the final

Table 1. Age & gender distribution

Age(years)	Male	Female	Total
Less than 6	7	0	7(19%)
6~8	14	4	18(49%)
More than 8	8	4	12(32%)
Total	29(78%)	8(22%)	37(100%)

Table 2. Catterall group at surgery

Catterall group	No. of Hips
I	0(0%)
II	2(5%)
III	23(62%)
IV	12(33%)
Total	37(100%)

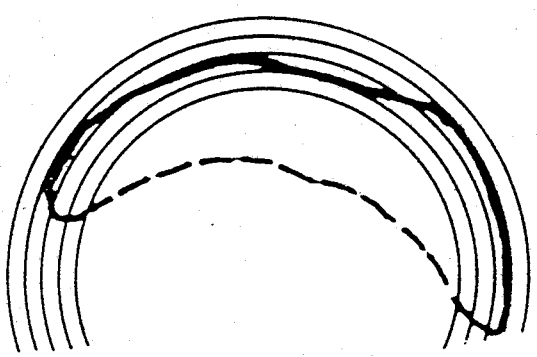


Fig. 1. *Measurement of the roundness of femoral head using Mose template. Concentric rings 2 mm apart are super-imposed on the femoral head on the radiograph.*

radiographs, the roundness of the femoral head was measured using the concentric ring template (Mose, 1980) of Mose (Fig. 1).

A good result by this method was taken as one in which the femoral head did not deviate by more than 2 mm from a circle in both the anteroposterior and lateral views. A fair result was a deviation between 2mm and 4mm in one or both views. A poor result was one in which there was more than 4mm deviation. In addition to evaluation for the roundness of the femoral head, we carried out comprehensive evaluation of the center-edge angle of Wiberg (Wiberg, 1939) and the epiphyseal extrusion (Green *et al.* 1981) to assess the degree of hip subluxation before surgery and at final follow-up (Fig. 2, 3).

The clinical results were assessed by final hip functions with respect to sitting, walking, running and ability to climb stairs. A good clinical result was one in which the diseased hip caused no symptoms and had a full, or almost full range of motion. A fair result was where the hip was asymptomatic but had slight restriction of movement especially in internal rotation. A poor clinical result was defined as one in which the findings indicated the presence of pain at rest or pain on motion, with limitation of motion.

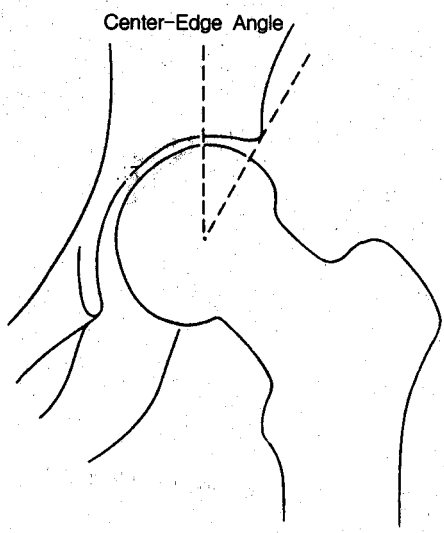
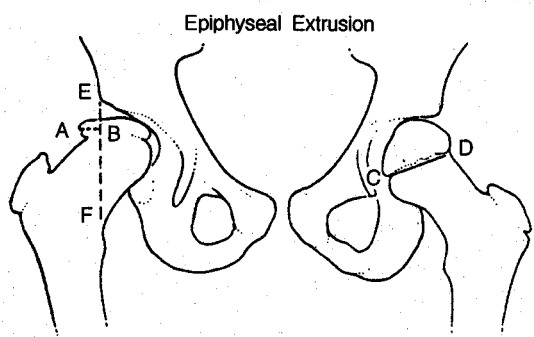


Fig. 2. *The center-edge angle is formed by a vertical line through the center of the femoral head and another line that begins at this point and extends to the outer edge of the acetabulum.*



$$E_E = \frac{AB}{CD} \times 100$$

Fig. 3. *Epiphyseal extrusion represents the proportion of the femoral head that is lateral to the acetabulum.*

Table 3. Radiological outcomes by age (<6 years)

Author	No. of Hips	Results (Mose assessment)		
		Good	Fair	Poor
Ingman *et al.* (1982)	11	7	4	0
Robinson *et al.* (1988)	11	10	0	1
Sponseller *et al.* (1988)	16	5	9	2
Paterson *et al.* (1991)	15	10	5	0
Park* *et al.* (1996)	7	5(71%)	2(29%)	0(0%)

RESULTS

Radiological results in our series clearly showed that the sphericity of the femoral head in the older age group was poorer, which is similar to other reports (Table 3~5 *: Authors' study).

Clinical results showed a tendency toward poorer results in the older age group(Table 6).

Radiological outcomes clearly showed that there were better results in the younger age group (Fig. 4-a, b, c and Fig. 5-a, b, c).

On the basis of the clinical outcomes, it may be concluded that good or fair results were obtained in 92% of the patients and poor results were found in 8%.

These results demonstrate a similar pattern to the clinical results which showed a trend toward poorer results in the older age group.

Epiphyseal extrusion and center-edge angle revealed improvement postoperatively (Table 7, 8).

It was evident that innominate osteotomy improved the results in hips with more than 20% epiphyseal extrusion.

At final follow-up, center-edge angles were

Table 4. Radiological outcomes by age (6~8 years)

Author	No. of Hips	Results (Mose assessment)		
		Good	Fair	Poor
Ingman *et al.*(1982)	13	4	7	2
Robinson *et al.*(1988)	12	12	0	0
Sponseller *et al.* (1988)	22	2	13	7
Paterson *et al.* (1991)	11	5	5	1
Park* *et al.* (1996)	18	8(44%)	6(33%)	4(23%)

Table 5. Radiological outcomes by age (>8 years)

Author	No. of Hips	Results (Mose assessment)		
		Good	Fair	Poor
Ingman *et al.*(1982)	14	3	4	7
Robinson *et al.*(1988)	2	1	0	1
Sponseller *et al.* (1988)	11	1	6	4
Paterson *et al.* (1991)	1	0	1	0
Park* *et al.* (1996)	12	1(1%)	6(50%)	5(42%)

Table 6. Clinical outcomes

Age	No. of Hips	Results		
		Good	Fair	Poor
Less than 6	7	7(100%)	0(0%)	0(0%)
6~8	18	13(72%)	4(22%)	1(6%)
More than 8	12	5(42%)	5(42%)	2(16%)
Total	37	25(68%)	9(24%)	3(8%)

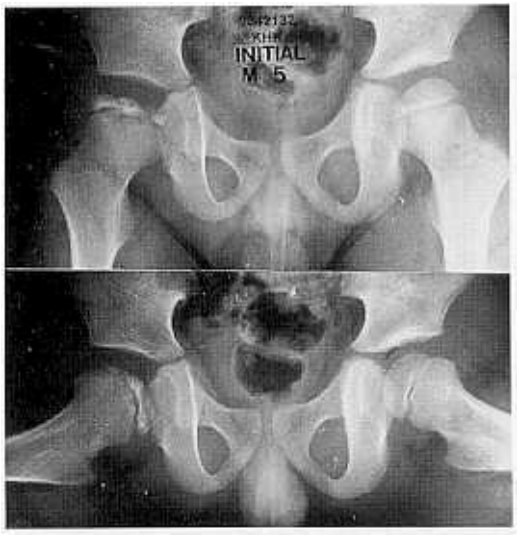


Fig. 4-a. *Anteroposterior and frog-leg lateral radiograms of the hip in a 5 year old boy. Right capital femoral epiphysis was collapsed and classified as Catterall group IV.*

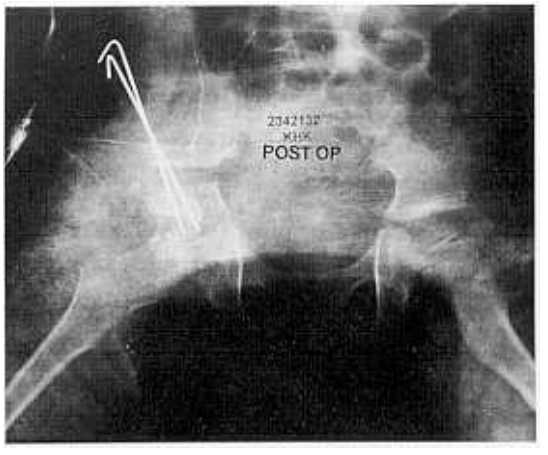


Fig. 4-b. *Immediate postoperative radiogram showing coverage of the femoral head with derotated acetabulum.*

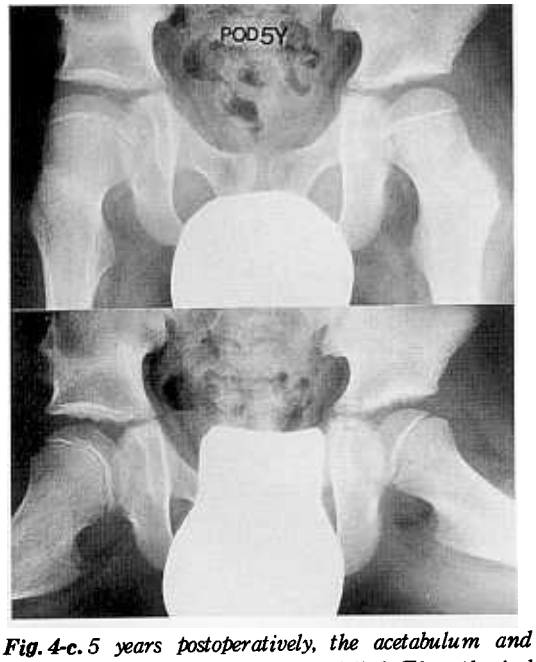


Fig. 4-c. *5 years postoperatively, the acetabulum and femoral head were remodelled. The spherical femoral head was concentrically contained within the acetabulum.*

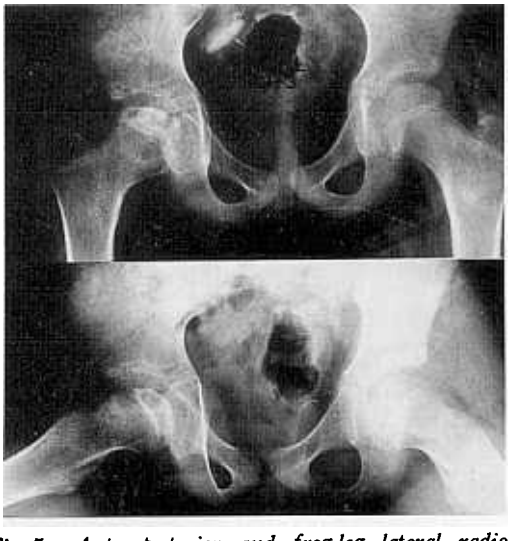


Fig. 5-a. *Anteroposterior and frog-leg lateral radiograms of the hip in a 9 year old girl. Right capital femoral epiphysis was collapsed and classified as Catterall group III.*

20 degrees or more in 29 of the 37 patients. Seventy-eight percent of the patients had improved femoral head coverage and provided good femoral head coverage in the weight-bearing position

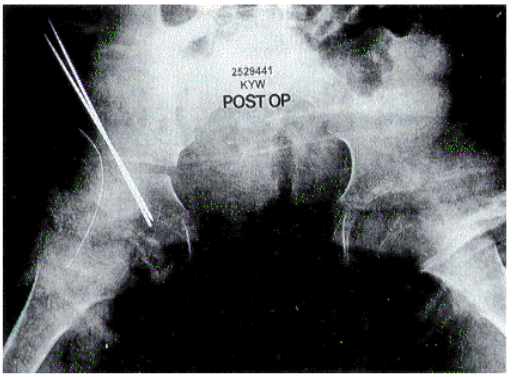


Fig. 5-b. *Immediate postoperative radiogram showing coverage of the femoral head with derotated acetabulum.*

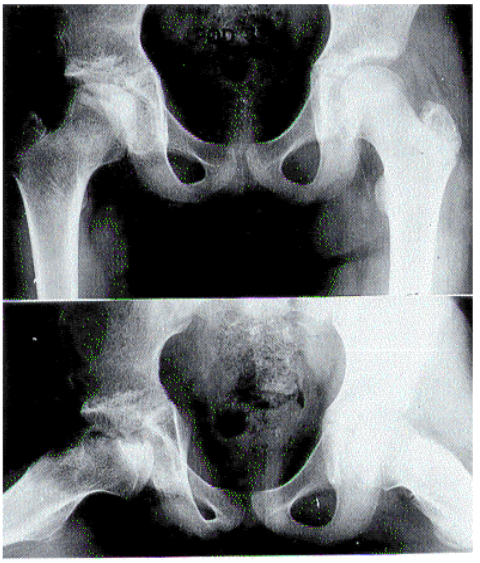


Fig. 5-c. *3 years postoperatively, the femoral head was concentrically contained within the acetabulum, but not spherical.*

Table 7. Epiphyseal extrusion

Epiphyseal extrusion (percent)	No. of Hips	
	Pre-op.	Final F/U
<20	5(13%)	17(46%)
20~25	7(19%)	11(30%)
>25	25(68%)	9(24%)
Total	37(100%)	37(100%)

Table 8. Center-edge angle

C-E angle (degree)	No. of Hips	
	Pre-op.	Final F/U
<20	29(78%)	8(22%)
20~25	6(16%)	10(27%)
>25	2(6%)	19(51%)
Total	37(100%)	37(100%)
Range	−7~31	12~39

DISCUSSION

Legg-Calvé-Perthes disease (LCPD) is currently best defined as idiopathic avascular necrosis or osteonecrosis of the capital femoral epiphysis, either partial or total, and the associated complications thereof occurring in a young growing child (Wynne-Davis and Gormley, 1978; Sutherland *et al.* 1980). It is a common pediatric hip disorder but, unfortunately, its aetiology is quite controversial and not well understood. But basic treatment principles for involved children are well accepted among orthopaedists, and they are ① elimination of hip irritability; ② restoration and maintenance of a good range of hip motion; ③ prevention of femoral head extrusion or subluxation; and ④ the attainment of a spherical femoral head at the completion of the disease process.

Unless one of the currently available three containment methods (orthotic, femoral osteotomy and innominate osteotomy) is precluded by limited hip motion or adverse radiologic features, the orthopaedist can feel free to use the method that works best for the patient (Salter, 1980; Rab, 1981; Wenger, 1981; Ippolito *et al.* 1987).

The selection of surgical methods of con-

tainment is based on the institutional approach in which the surgeon was trained and his technical expertise. Among them, the innominate osteotomy is applicable in the more severe forms of LCPD early in the disease process. It is a derotational osteotomy, and does not enlarge the acetabular capacity. By doing an innominate osteotomy the direction of the acetabulum is changed so that the femoral head can be permanently contained within the acetabulum. Rab *et al.*(1985) used computerized simulations of hip orientation and joint movement to show that, after innominate osteotomy, anterior coverage of the femoral head during standing and walking is increased by 25 degrees and lateral coverage is increased by 5 to 15 degrees, depending on the phase of the gait. He found that the femoral head was contained anterolaterally in a functional weight-bearing position, while the forces transmitted through the hip joint were unaltered. In our series, 51% of the patients after innominate osteotomy had an center-edge angle of 25 degrees or more when the head healed, comparing 94% of patients less than 25 degrees preoperatively. Salter and Brown (1986) reported long-term results on 159 hips treated by innominate osteotomy prior to femoral head deformity. All children were 6 years of age or older with Catterall groups III and IV involvement. At follow-up, 93% of the patients were asymptomatic and 97% had satisfactory radiologic results.

Regarding the age factor, many authors reported good results with various treatment modalities in patients who were under 6 years (Lloyd-Roberts *et al.* 1976; Salter *et al.* 1977; Thompson and Salter, 1987). Our series also showed excellent results in the younger age group, which suggest that young age is one of the most important prognostic factors in LCPD, and this fact is thought to be attributed to the amount of remaining growth and the opportunity for femoral head remodelling. In patients who were six, seven, or eight, our results were not always satisfactory, and in patients who were nine years old or more, our results were poorest. We think that the patients in this older age group who have an advanced stage of the disease do not necessarily seem to benefit from innomimate osteotomy and that acetabular remodelling may be insufficient in this age group.

With an epiphyseal extrusion of more than 20%, anterolateral coverage by innominate osteotomy may uncover the femoral head posteriorly (Wenger, 1981). Subluxation of the femoral head, as indicated by an epipyseal extrusion of more than 20%, was corrected in favorable improvement of our series. Two patients with poor clinical and radiologic results were the severe cases in the older age group (more than 8 years) and having an epiphyseal extrusion more than 20%.

The practice of combining a femoral osteotomy with a pelvic osteotomy in the treatment of LCPD was first reported in 1974 by Craig and Kramer. Crutcher and Staheli (1992) reported combined femoral and pelvic osteotomy as a safe and effective salvage procedure in severe LCPD. They described that the addition of either osteotomy provided adequate containment in patients with severe disease and lateral subluxation. The theoretical advantage of a combined osteotomy in severe LCPD is that maximal femoral head containment may be achieved while avoiding some of the complications of either procedure alone (Craig and Kramer, 1974; Marklund and Tillberg, 1976; Wenger, 1981; Mirovsky *et al.* 1984; McElwain *et al.* 1985; Crutcher and Staheli, 1992). In our series, most of the patients who revealed poor results were the cases who could not have adequate coverage with innominate osteotomy alone, and should have an extreme internal rotated hip position within the cast to acquire a coverage by the derotated acetabulum. And so, we think that additional proximal femoral varus derotational osteotomy with innominate osteotomy in the older age group and/or severe disease group would be beneficial and produce better results than our present report. We wish to emphasize that this study was concerned only with the innominate osteotomy for LCPD.

Perhaps the most controversial area in the study of LCPD concerns the long-term results of the current methods of treatment. The most prevalent questions regarding results include : ① Does containment actually improve

results when compared with the natural course of the disease process; and ② If treatment does improve results, which of the various methods of containment is the best and why? Many satisfactory reports regarding containment treatment give an answer to the first question. But the answer to the second question is more difficult and cannot be satisfactorily answered at this time. Of course, non-operative management can also have a role in treatment of the disease, as can secondary or salvage procedure such as valgus osteotomy, trochanter transfer, and possibly the Chiari or Shelf procedure. In our series, the abduction braces were discarded at the average of 6 months postoperatively, when the reossification of the lateral column starts. But Thompson and Westin (1979) reported several cases which showed femoral head collapse after cessation of the brace in the early reossification phase. We occasionally saw the patients similar to the reports of Thompson and Westin. We think that careful determination of time of discarding the brace is very important, especially in the cases with older and more severely affected patients.

In conclusion, we recommend that patients who need containment be identified carefully, and suggest that innominate osteotomy is a safe and reproducible procedure in LCPD if the procedure be carefully selected as a surgical method in children under 9 years.

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