THE COLONNA-HEY GROVES ARTHROPLASTY IN THE LATE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP

A LONG-TERM REVIEW

J. L. POZO, S. R. CANNON, A. CATTERALL

From the Royal National Orthopaedic Hospital, London

Forty-four patients who had undergone 50 capsular arthroplasties for congenital dislocation of the hip were reviewed after a mean follow-up of 20 years. Their average age at operation was 5.9 years; 31 of the operations were undertaken because of late presentation, the remainder because of the failure of previous surgery. In all, 70% of the hips showed good function despite a reduced range of movement, but patients with bilateral arthroplasties fared poorly. Excellent containment within the acetabulum was found in 80%, but the femoral head was always abnormally high though not unduly lateral or medial. This configuration had remained unchanged during follow-up. The accuracy of reduction along the mediolateral axis was the only variable found to influence the outcome significantly. Functional deterioration, associated with pain, was noted to be more common after 20 years than before, and was associated with radiographic evidence of joint degeneration.

The management of the older child with congenital dislocation of the hip, delayed either because of late presentation or by previous and unsuccessful surgery, remains difficult and controversial. There is nevertheless, agreement that in unilateral cases, reduction should be attempted up to the age of 10 years (Sharrard 1979) and possibly to an upper limit of 14 years (Lloyd-Roberts 1978).

Many of the operations designed to secure reduction and containment are known to achieve satisfactory early results, especially in children under the age of six years. These include open reduction combined with re-orientation of the acetabulum (Salter 1961; Pemberton 1965, 1974), or with an acetabuloplasty (Trevor, Johns and Fixsen 1975) or the addition of a superior buttress (Bosworth et al. 1961; Wilson 1974). Such techniques have also been used, though less frequently, in the older child with a high dislocation. In this age group, Klisić (1982) has combined a one-stage femoral shortening with

either an acetabuloplasty or medial displacement osteotomy of the ilium to reduce the risk of avascular necrosis. A radically different approach is represented by the capsular arthroplasty (Hey Groves 1927; Colonna 1932), which aims to relocate the capsule-covered femoral head within a surgically deepened acetabulum. An objective evaluation of these different methods of treatment in the older age-group is difficult in the absence of comparable long-term studies.

At the Royal National Orthopaedic Hospital, London, the Colonna-Hey Groves capsular arthroplasty has been employed for many years in the surgical management of the older child with a high dislocation, often following previously failed surgery. This study presents a mean 20-year clinical and radiographic follow-up of 50 capsular arthroplasties, previously reported in the short-term by Trevor (1968).

PATIENTS

Sixty-three patients who had undergone arthroplasties before 1974 were identified from hospital records. In order to assess of the role of the arthroplasty in congenital dislocation alone, six patients with subluxation, one with arthrogryposis and one with dislocation after sepsis were excluded. One patient had died of an unrelated cause and 10 could not be traced.

There were therefore 44 patients who had had a total

J. L. Pozo, FRCS, Orthopaedic Senior Registrar
S. R. Cannon, FRCS, Orthopaedic Senior Registrar
A. Catterall, FRCS, Consultant Orthopaedic Surgeon
The Royal National Orthopaedic Hospital, 45-51 Bolsover Street,
London W1P 8AQ, England.

Requests for reprints should be sent to Mr A. Catterall.

© 1987 British Editorial Society of Bone and Joint Surgery
0301-620X/87/2039 \$2.00

of 50 arthroplasties (six bilateral) available for clinical review. Of these, 39 were girls and 5 boys, while 32 operations were on the right hip and 18 on the left. In the group of patients who had unilateral arthroplasties, eight also had a contralateral dislocation, and two a severe subluxation; all these were treated by other methods. The average age at the time of arthroplasty ranged from 3 years 9 months to 10 years 3 months, with an average of 5.9 years (Fig. 1). Follow-up spanned 12 to 34 years, with an average of 19.75 years.

Fig. 1

Age distribution at the time of capsular arthroplasty. Salvage or secondary operations are cross-hatched.

The age at diagnosis varied from birth to seven years (mean 3.2 years). In 31 hips the Colonna-Hey Groves arthroplasty was the primary operation because of late presentation. In the remaining 19 hips, the operation was employed as a salvage procedure following previous unsuccessful operations (Fig. 1). These had included 14 open reductions (often in combination with femoral osteotomy), five shelf operations, three Pemberton acetabuloplasties, and one Salter osteotomy. The capsular arthroplasty represented the fifth surgical procedure in one case and the sixth in another patient.

METHODS

Clinical assessment. Function was assessed at the clinical review in terms of the Harris (1969) and the Iowa (Larson 1963) scales. Though these scales are complex, detailed, and were not originally described for cases of congenital dislocation, it was felt that, being internationally recognised, they would provide an objective and standard basis for comparison with other studies.

Radiographic assessment. All pre-operative and post-

reduction radiographs were obtained for review. Radiographs spanning the period of follow-up were also available for most patients. At the time of clinical examination, anteroposterior and lateral radiographs of both hips were taken. Where the criteria of Tönnis (1976) were satisfied, the radiographs were measured for the following indices over the period of follow-up:

1. The spatial configuration of the femoral head and acetabulum within the pelvis (Smith et al. 1968).
2. The centre-edge (CE) angle (Wiberg 1953).
3. The Severin classification (Severin 1941).
4. Sharp's acetabular angle (Sharp 1961).
5. The epiphyseal index of the femoral head (Heyman and Herndon 1950).

In addition the final radiograph was scrutinised for degenerative change, congruity and containment of the femoral head.

RESULTS

Early postoperative course. In the five years after operation, there was subjective and objective evidence of improving hip movement and function, with increasing strength in the operated leg. Most patients (65%) described their school days as normal, with active participation in most sports. These included tennis, netball and athletics, with skiing in some instances. Many of the patients continued to play some sport, usually tennis, after leaving school.

Nine patients underwent abduction or rotation femoral osteotomy between 4 and 10 years after the Colonna arthroplasty in order to improve the biomechanics of the hip. In two cases this was undertaken to overcome arthrographically demonstrated "hinged abduction" (Catterall 1982). One patient had femoral lengthening for significant leg-length discrepancy. The average leg-length discrepancy for the group of patients with unilateral operations was, however, only 1.6 cm.

Final clinical assessment. Function was assessed in terms of the Harris and the Iowa scales. Statistical analysis showed no significant difference between the two scores, so the final evaluation was based on the mean of both.

Table 1. Functional assessment of 50 hips on the Harris and Iowa scales at a mean of 20 years after capsular arthroplasty

Result	All hips (50)		Unilateral (38) Per cent	Bilateral (12) Per cent
	Number	Per cent		
Excellent	24	70	76	42
Good	11			
Fair	4	20	24	58
Poor	6			
Total replacement	5	10

Fig. 2

Histogram showing function related to length of follow-up. Cases with a functional score of less than 80 are cross-hatched.

The functional status of the 50 hips at an average of 20 years after arthroplasty is given in Table I. In all, 70% of hips showed an excellent or good outcome, while 30% had reached a point of failure as indicated by a fair or poor result or conversion to a total hip replacement. Comparing the results of bilateral and unilateral operations showed that patients fared poorly after bilateral procedures, with only 42% having a satisfactory outcome. This finding may reflect the observation that a stiff painless hip often presents little handicap, whereas two stiff hips are a serious impediment to normal function. Because of the small numbers in the bilateral group, this difference did not reach statistical significance.

Range of movement. Only 38% of the hips showed a normal range of movement when assessed separately on the Harris scale; 42% showed a significant reduction and 20% a severe restriction. Retrospective analysis revealed that there had been little deterioration in the ranges during the period from 5 to 20 years after the arthroplasty.

Function in relation to time. There had been little subjective or objective change in the function and performance of the hips during the first 20 years after arthroplasty. At this point only 18% of patients had an unsatisfactory result, but in the group followed for more than 20 years over 55% of the patients had a poor performance or had undergone a replacement arthroplasty (Fig. 2).

Radiographic assessment. Position of the hip within the pelvis. The spatial relationship of the femoral head and reconstructed acetabulum within the pelvis was defined before operation and at five-yearly intervals. Both horizontal and vertical components were recorded, using the grid described by Smith (Fig. 3). Analysis of the position of all 50 hips along the horizontal axis (c/b),

showed that all except three had been brought back within the normal range of 0.60 to 0.85 (Smith et al. 1968), with a mean reading of 0.68. Analysis of the position along the vertical axis (h/b) showed that the hips were abnormally high in the pelvis as reflected by a mean h/b value of -0.03 as compared with the normal range of $+0.10$ to $+0.20$ (Smith et al. 1968). These relative positions of the hips were maintained during the subsequent period of follow-up (Figs 4 and 5).

Fig. 3

The grid for determination of the spatial orientation of the hip in the pelvis (Smith et al. 1968).

c - distance from the centre line to the medial margin of the upper femoral metaphysis;

h - distance from the upper margin of the femoral metaphysis to Hilgenreiner's line;

b - distance from the centre line to the most lateral edge of the acetabulum;

The mediolateral position is recorded as c/b , the vertical position as h/b .

Fig. 4

Mean mediolateral positions (c/b) and mean vertical positions (h/b) for the 50 abnormal hips pre-operatively and over a follow-up of 15 years, compared with normal values.

Fig. 5

Position of the femoral head within the acetabulum. A modified Severin classification, based on the CE angle of Wiberg (1953), was employed to assess the spatial configuration or containment of the femoral head within the acetabulum before operation, after the capsular arthroplasty and at a mean of 20 years postoperatively.

At the final review 39 of the hips (78%) had a normal spatial relationship (Table II), although the 26 patients in Severin Group II had some deformity of the femoral head, neck or acetabulum. A dysplastic acetabulum was seen in 16% of cases, with a further 4% showing evidence of subluxation. Eight of the 10 poor results were in Severin Group I at early review, without any features by which to forecast later deterioration.

Comparison of the final results in groups above and below the age of five years at the time of the arthroplasty showed that the younger age group had a slightly better outcome.

Table II. The Severin classification of 50 hips, all in Group VI (dislocated) before arthroplasty, at a mean of 20 years postoperatively

Severin group	Number of hips*	Per cent
Group I: Normal. CE angle > 25°	13	26
Group I: Moderate deformity of head, neck or acetabulum but with CE angle > 25°	26	52
Group III: Dysplastic without subluxation, CE angle < 20°	8	16
Group IV: Subluxated Moderate: CE angle positive or zero Severe: CE angle negative	2	4

* One hip became ankylosed three years after operation
CE, centre-edge angle of Wiberg

Development of the femoral head. The epiphyseal index (Heyman and Herndon 1950) was used to measure the shape of the femoral epiphysis before the arthroplasty and just prior to epiphyseal closure (Fig. 6). On this scale 48% of the dislocated femoral heads had an index greater than the upper limit of normal, taken as 45 to 55 in children less than seven years old (Eyre-Brook 1936).

Fig. 6

The epiphyseal index (Heyman and Herndon 1950) before arthroplasty and at epiphyseal closure.

This reflects the "acorn-shaped" appearance of the epiphysis described both radiographically (Fig. 7) and at operation (Colonna 1965; Trevor 1968). In the final analysis, 69% of the hips had an index less than the lower limit of normal (35 to 45 in the adolescent), which represents a marked flattening of the epiphysis. This occurred despite the absence of major avascular necrosis in all but one case.

Joint degeneration. In view of the abnormal appearance of the acetabulum, degenerative change was defined by the presence of femoral cysts, with none present in the contralateral normal hip, and by a reduction of over 50% in the width of the joint space. At final review, 60% showed some evidence of degeneration, but only 12 patients exhibited both features and their average follow-up was 22 years.

Correlation of clinical and radiographic findings. The clinical and radiographic status of the hips remained largely unchanged for approximately 20 years (Figs 8 and 9). However, the onset of pain in association with radiographic degeneration heralded serious clinical deterioration. Within a relatively short time, usually five years, functional and radiographic deterioration warranted further surgical intervention (Fig. 10). Five patients in this series have had total replacement of the affected hip.

Complications. Although 34 patients showed flattening of the femoral head, only one girl developed unmistakable

evidence of avascular necrosis which affected the whole of the epiphysis. Nevertheless, 15 years later she had an excellent functional result (Fig. 11). One patient who underwent bilateral Colonna operations at the age of 10 years, developed a spontaneous ankylosis of the left hip three years after the operation.

Multiple regression statistical analysis. No correlation was found between the functional outcome of the operation and the following variables: sex, side, age at

Fig. 7

Case showing an acorn-shaped femoral epiphysis with a high epiphyseal index before (1968) and soon after (1969) arthroplasty. By the time the epiphysis had closed (1984) flattening had occurred without evidence of avascular necrosis.

Fig. 8

Series of radiographs of a patient followed for 20 years after unilateral arthroplasty. There was a good functional result.

operation, whether primary or secondary operation, femoral epiphyseal index, pre-operative Sharp's angle and the vertical displacement of the hip (h/b in Fig. 3). The only variable which appeared to affect the outcome of the operation was the postoperative position of the femoral head along the horizontal axis (c/b in Fig. 3). The better the reduction within the pelvis, that is the smaller the ratio c/b, the better was the functional outcome (Fig. 12).

DISCUSSION

In the study of congenital dislocation of the hip, short-term clinical review has only limited relevance to the long-term outcome (Gibson and Benson 1982). Similarly, we found that the majority of patients had a satisfactory result, with little change in the clinical or radiographic status of the hip, until 20 years after their arthroplasty. Evaluation of reported short-term results is further complicated by different methods of assessment.

Fig. 9

Radiographs of a patient with bilateral arthroplasty followed for 19 years after the second side. Function on both sides was good.

Fig. 10

Radiographs to show progressive degenerative change, after arthroplasty, leading to total joint replacement.

Fig. 11

Avascular necrosis of the epiphysis in a 5-year-old child. After 15 years (below) there is a good functional and radiographic result.

Nevertheless, despite a wide variation in results, the larger published series indicate a satisfactory outcome in 55% to 75% of patients reviewed at an average of 10 years (Chigot and Vialas 1966; Ritter and Wilson 1968; Trevor 1968; Lagrange et al. 1973; Dal Monte, Campanacci and Manes 1975; Kalman 1976).

The Harris (1969) and the Iowa (Larson 1963) scales, though widely employed in the analysis of results, are open to criticism because they were not originally described in the context of congenital dislocation; also the clinical assessment of range of movement represents only 9% and 15% of each score respectively. This may account, in part, for the high proportion of good results (70%) despite the smaller percentage of hips (38%) with a normal range of movement. Bilaterally stiff hips however, even when painless, cause sufficient loss of function to be registered as poor results. Chung et al. (1971) in their review of Colonna's patients reported 55% good results, but also found a poor rating in bilateral cases.

Separate analysis of primary and salvage operations fails to provide conclusive prognostic information. Both Chigot and Vialas (1966) and Desgrippes and Bensahel (1973) report better results in the primary group, but we agree with the findings of Ritter and Wilson (1968) and of Glass and Dunningham (1980) who reported little difference in the final outcome between the two groups.

Capsular arthroplasty is successful in achieving centralisation and stabilisation of the hip at the level of the triradiate cartilage, but it cannot produce a normal

joint. Although the hip is placed somewhat high in the pelvis, we found that the significant factor was its position along the mediolateral axis: the more accurate the reduction in this axis, the better the functional outcome. Once achieved, this configuration was maintained with little tendency towards protrusio or subluxation. Further development of the reconstructed acetabulum produced a remarkably well-contained joint despite the relatively reduced growth potential and adaptive capacity of the acetabular roof in the older child. None of

Fig. 12

Relationship between functional outcome by the Harris score and the mediolateral orientation of the hip. The better the reduction (the smaller the ratio c/b), the more successful is the result.

our patients suffered a redislocation even though two-thirds of them had previously undergone multiple attempts at reduction. In the short term, comparison with such forms of treatment as innominate osteotomy or Pemberton arthroplasty by the use of the Severin classification is inappropriate because these procedures depend on acetabular growth to provide bony cover for the femoral head.

The high epiphyseal index recorded in many of the dislocated hips reflects the acorn shape of the femoral head often seen at operation (Trevor 1968; Chung et al. 1971) which is presumed to be secondary to the absence of acetabular moulding. Although the flattening of the femoral head seen later has been widely ascribed to avascular necrosis (Ritter and Wilson 1968; Lagrange et al. 1973; Dal Monte et al. 1975), our study failed to define such changes, except in one patient where the whole epiphysis was involved.

It is likely that the new acetabular surface is derived from chondrocytic activity at the triradiate cartilage and in residual elements in the periphery of the acetabulum (Mankin 1962). Large defects are repaired by the formation of hypercellular hyaline-like cartilage whose features are influenced by the size of the defect (Convery, Akeson and Keowin 1972) and by the biomechanical stresses imposed on the articulating surfaces (Hughes 1974). This chondroid tissue soon becomes more fibrous (Mitchell and Shepard 1976) and the incongruity of the joint elements accelerates degeneration of the fibrocartilage. This may explain the relatively uniform time-scale over which degenerative change appears in the operated hips. Unfortunately, no material from an acetabular surface has become available for histological examination.

Evaluation of the different treatment methods remains inconclusive in the absence of comparable long-term studies, and is often complicated by the inclusion of cases of both subluxation and dislocation within the same analysis. Salter recommends that innominate osteotomy be performed for dislocation under the age of six years. In a series of 30 hips in children aged 4 to 10 years, he reported 57% good results over a follow-up period of 5.5 years (Salter and Dubos 1974). The Pemberton osteotomy, technically more difficult and complicated by closure of the triradiate cartilage, results in excessive joint deformity when it is used for the older patient (McKay 1982). A long-term review of the shelf procedure in children with a mean age of 7.5 years found poor results in 57% of patients; 50% had symptomatic degenerative changes by 20 years after operation (White and Sherman 1980). In our experience the long-term outcome of acetabuloplasty in the older child also appears to be unsatisfactory (Catterall, unpublished data). The addition of femoral shortening to these techniques shows promise of improved results, but as yet these are only short-term.

The Colonna-Hey Groves arthroplasty provides a

highly satisfactory level of function, despite a reduced range of movement, for over 20 years. Once clinical and radiographic deterioration appear patients often require further major surgery within five years. Conversion to a replacement arthroplasty is then a much easier procedure than it is from a high unreduced dislocation. The value of the capsular arthroplasty as a salvage procedure when other operative measures have failed has been clearly demonstrated. Its role, however, in the management of the older child with an untreated dislocation remains to be defined in the light of future studies.

The authors wish to thank Dr Brian Birkhead, PhD, of University College, London for his assistance with the statistical analysis of the clinical data, and the photographic department of the Royal National Orthopaedic Hospital for the excellent reproduction of the radiographs.

REFERENCES

- Bosworth DM, Fielding JW, Ishizuka T, Ege R. Hip-shelf operation in adults. *J Bone Joint Surg [Am]* 1961;43-A:93-106.
- Catterall A. *Legg-Calvé-Perthes disease*. (Current problems in orthopaedics). Edinburgh etc: Churchill Livingstone, 1982.
- Chigot PL, Vialas M. Les résultats tardifs de l'intervention de Colonna. *Ann Chir* 1966;20:1446-52.
- Chung SMK, Scholl HW Jr, Ralston EL, Pendergrass EP. The Colonna capsular arthroplasty: a long-term follow-up study of fifty-six patients. *J Bone Joint Surg [Am]* 1971;53-A:1511-27.
- Colonna PC. Congenital dislocation of the hip in older subjects: based on a study of 66 open operations. *J Bone Joint Surg* 1932;14:277-98.
- Colonna PC. Capsular arthroplasty for congenital dislocation of the hip: indications and technique: some long-term results. *J Bone Joint Surg [Am]* 1965;47-A:437-49.
- Convery FR, Akeson WH, Keowin GH. The repair of large osteochondral defects: an experimental study in horses. *Clin Orthop* 1972;82:253-62.
- Dal Monte A, Campanacci M, Manes E. Treatment of C.D.H. in children between five and ten years of age. *Chir Organi Mov* 1975;62:517-25 (In Italian with English summary).
- Desgrappes Y, Bensahel H. Résultats éloignés de l'arthroplastie de Colonna dans la luxation congénitale de la hanche. *J Chir (Paris)* 1973;105:157-66.
- Eyre-Brook AL. Osteochondritis deformans coxae juvenilis or Perthes' disease: results of treatment by traction in recumbency. *Br J Surg* 1936;24:166-82.
- Gibson PH, Benson MKD. Congenital dislocation of the hip: review at maturity of 147 hips treated by excision of the limbus and derotation osteotomy. *J Bone Joint Surg [Br]* 1982;64-B:169-75.
- Glass A, Dunningham TH. Capsular arthroplasty of the hip for congenital dislocation. *Isr J Med Sci* 1980;16:328-32.
- Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty: an end-result study using a new method of result evaluation. *J Bone Joint Surg [Am]* 1969;51-A:737-55.
- Heyman CH, Herndon CH. Legg-Perthes disease: a method for the measurement of the roentgenographic result. *J Bone Joint Surg [Am]* 1950;32-A:767-8.
- Hey Groves EW. Reconstructive surgery of the hip. *Br J Surg* 1927;14:486-517.
- Hughes JR. Acetabular dysplasia in congenital dislocation of the hip. *Proc R Soc Med* 1974;67:1178-80.

- Kalman E.** Neskore výsledky po acetabuloplastikách podľa Colonna. *Bratisl Lek Listy* 1976;65:655-68. (Eng. Abstr.) (Slo).
- Klisić P.** Open reduction with femoral shortening and pelvic osteotomy. In: Tachdjian MO, ed. *Congenital dislocation of the hip*. New York etc: Churchill Livingstone, 1982:417-26.
- Lagrange J, Rigault P, Loisel P, Pouliquen J-C, Guyonvarch G.** Notre expérience de l'opération de Colonna dans le traitement de la luxation congénitale de la hanche chez l'enfant: résultats de 69 interventions suivies plus de 2 ans. *Rev Chir Orthop* 1973;59:353-73.
- Larson CB.** Rating scale for hip disabilities. *Clin Orthop* 1963;31:85-93.
- Lloyd-Roberts GC.** Congenital dislocation of the hip and associated conditions. In: Lloyd-Roberts GC, Ratliff AHC, eds. *Hip disorders in children*. London etc: Butterworths, 1978:35-90.
- McKay DW.** Pemberton's innominate osteotomy: indications, technique, results, pitfalls and complications. In: Tachdjian MO, ed. *Congenital dislocation of the hip*. New York etc: Churchill Livingstone, 1982:543-54.
- Mankin HJ.** Localization of tritiated thymidine in articular cartilage of rabbit. II. Repair of immature cartilage. *J Bone Joint Surg [Am]* 1962;44-A:688-98.
- Mitchell N, Shepard N.** The resurfacing of adult rabbit articular cartilage by multiple perforations through subchondral bone. *J Bone Joint Surg [Am]* 1976;58-A:230-3.
- Pemberton PA.** Pericapsular osteotomy of the ilium for treatment of congenital subluxation and dislocation of the hip. *J Bone Joint Surg [Am]* 1965;47-A:65-86.
- Pemberton PA.** Pericapsular osteotomy of the ilium for the treatment of congenitally dislocated hips. *Clin Orthop* 1974;98:41-54.
- Ritter MA, Wilson PD Jr.** Colonna capsular arthroplasty: a long-term follow-up of forty hips. *J Bone Joint Surg [Am]* 1968;50-A:1305-26.
- Salter RB.** Innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. *J Bone Joint Surg [Br]* 1961;43-B:518-39.
- Salter RB, Dubos JP.** The first fifteen years' personal experience with innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. *Clin Orthop* 1974;98:72-103.
- Severin E.** Contribution to knowledge of congenital dislocation of hip joint: late results of closed reduction and arthrographic studies of recent cases. *Acta Chir Scand* 1941;84 Suppl 63:1-142.
- Sharp IK.** Acetabular dysplasia; the acetabular angle. *J Bone Joint Surg [Br]* 1961;43-B:268-72.
- Sharrard WJW.** Congenital and developmental abnormalities of the hip. Paediatric orthopaedics and fractures. Vol.1. 2nd ed. Oxford etc: Blackwell Scientific Publications, 1979:318-427.
- Smith WS, Badgley CE, Orwig JB, Harper JM.** Correlation of postreduction roentgenograms and thirty-one-year follow-up in congenital dislocation of hip. *J Bone Joint Surg [Am]* 1968;50-A:1081-98.
- Tönnis D.** Normal values of the hip joint for the evaluation of x-rays in children and adults. *Clin Orthop* 1976;119:39-47.
- Trevor D.** The place of the Hey Groves-Colonna operation in the treatment of congenital dislocation of the hip. *Ann R Coll Surg Engl* 1968;43:241-58.
- Trevor D, Johns DL, Fixsen JA.** Acetabuloplasty in the treatment of congenital dislocation of the hip. *J Bone Joint Surg [Br]* 1975;57-B:167-74.
- White RE Jr, Sherman FC.** The hip-shelf procedure: a long-term evaluation. *J Bone Joint Surg [Am]* 1980;62-A:928-32.
- Wiberg G.** Shelf operation in congenital dysplasia of the acetabulum and in subluxation and dislocation of the hip. *J Bone Joint Surg [Am]* 1953;35-A:65-80.
- Wilson JC Jr.** Surgical treatment of the dysplastic acetabulum in adolescence. *Clin Orthop* 1974;98:137-45.