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Cementless Total Hip Arthroplasty for Congenitally Dislocated or Dysplastic Hips

Technique for Replacement With a Straight Femoral Component

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A new straight cementless stem was used for replacement of 67 dislocated or severely dysplastic hips. There were 45 hips with complete dislocation, 27 of which were cases after Schanz osteotomy. Technical solutions for various deformities are presented here. The acetabular component was placed at the level of the original cotyloid cavity or some lower position. In hips after total dislocation a metaphyseal shortening osteotomy was combined with distal advancement of the greater trochanter with intact attachment of the abductor muscles. This method was appropriate also for the femora, where high-seated Schanz osteotomy was previously performed. If the diaphysis was too narrow for the stem, it was split about 10 cm both anteriorly and posteriorly. In cases with unilateral total dislocation where Schanz osteotomy had been seated low, metaphyseal segmental shortening with angular correction was performed and the stem was used as an intramedullary nail. Special attention was paid to achieve sufficient abduction strength to balance the pelvis and abolish Trendelenburg limp and to restore leg length. The clinical and radiographic results of the consecutive series were assessed three to five years after the arthroplasty. Pain relief and the functional results including improvement of gait were generally good, primary complications were few, but the loosening and revision rate of the smooth-threaded acetabular component was unacceptably high. There were no problems with the press-fit cups. In general the outcomes were good even when reoperation was required.

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There are many specific problems in replacement surgery of severely dysplastic or dislocated hips. The proximal femora are straight and the neck is short and anteverted. To get reliable fixation of the acetabular component and to achieve abduction strength strong enough to balance the pelvis, the cup must be seated near the anatomic level or even lower.[4,5,7,10–12,18,20,27] Therefore in most cases the femoral component must be mounted below the intertrochanteric level to reduce the prosthesis. At these levels the femoral shaft is straight, necessitating a straight stem.[4,5,11,27]

Cementless replacement of these problematic hips with Lord's madreporic stem was started in the Orthopaedic Hospital of the Invalid Foundation approximately ten years ago. This stem was the most appropriate of the cementless stems available at that time.[20] Even Lord's stem was too curved in many femora, causing splits around the tip of the stem and excessive bone loss in the proximal medial femur. To avoid these problems an entirely straight stem was designed by the senior author with Biomet, Inc. (Warsaw, Indiana). The new component and the operative techniques are presented, and the results of the first 67 replacements using this new stem are evaluated.

MATERIALS AND METHODS

From 1988 to 1989, 67 severely dysplastic or dislocated hips were replaced by Biomet's cementless prosthesis in the Orthopaedic Hospital of the Invalid Foundation, Helsinki. There were 60 patients, 55 women and five men. The mean age at operation was 52 years (range, 24–76). The indications for arthroplasty were severe hip pain, with considerable difficulty in walking and performing daily activities. All cases remained under clinical and radiographic review. The follow-up period ranged from three to five years. Pain and function was scored according to the Mayo Hip Score.[17] The total range of hip movements and Trendelenburg sign were also assessed. Leg length discrepancy was measured both clinically and radiographically.[15,16] During the measurement of clinical leg-length discrepancy, the patient stood with straight knees, and with feet parallel, 15 cm apart. A block of known thickness was placed under the shorter leg to equalize iliac crest levels. The thickness of the block was considered the clinical leg-length discrepancy. Radiographs were taken with the patient standing erect. If the patient was unable to stand in the correct position because of leg-length inequality or adduction contracture of the hip joint, a block of known thickness was placed under the shorter leg to prevent knee flexion and pelvic rotation. Radiographic true leg length inequality was defined as a difference in the heights of the highest points of the vertices of the femoral or prosthetic heads. The radiographic functional leg-length inequality was defined as a difference in the heights of the lowest points of the ischial tuberosities. Radiographic analysis of the prosthesis was performed according to DeLee and Charnley,[3] Tallroth *et al.*,[25] and Gruen *et al.*[8]

Prophylactic antibiotic therapy (flucloxacillin or clindamycin) was given two hours before operation and continued for 48 hours. Thromboembolic prophylaxis included Orstanorm heparin (dihydroergotamine with heparin), early mobilization, encouragement of active leg movement, and antiembolic stockings.

The most common cause of the hip deformity was congenital dislocation of the hip joint (58 hips). Four cases had old tuberculosis of the hip joint, three cases had congenital coxa vara, one had slipped femoral capital epiphysis, and one had Perthes disease. Multiple operations had been performed in childhood or later: open reduction of the hip joint in six, Schanz osteotomy in 27, Chiari pelvic osteotomy in one and intertrochanteric femoral osteotomy in seven cases. Hip deformities were classified according to Eftekhar.[5] Eighteen hips were of Eftekhar Stage B, 17 of Stage C, and 28 of the most severe deformity, classified as Stage D. Deformation of the hip caused by congenital coxa vara and slipped femoral capital epiphysis could not be graded according to Eftekhar.

The prosthetic stem, made of titanium alloy, has a wedge shape of three degrees with collar. The proximal third is coated by plasma spray and is oval in section, 12 mm thick, and breadths are available from 13 to 19 mm to suit the size of the femur. The neck angle is 135°, the off-set of the stem varies from 31 to 39 mm according to the modular head. The length of the intramedullary part of the stem is 15 cm (Fig. 1).

Operative methods are essentially the same as those with Lord's prosthesis.[20] Diagrams of the

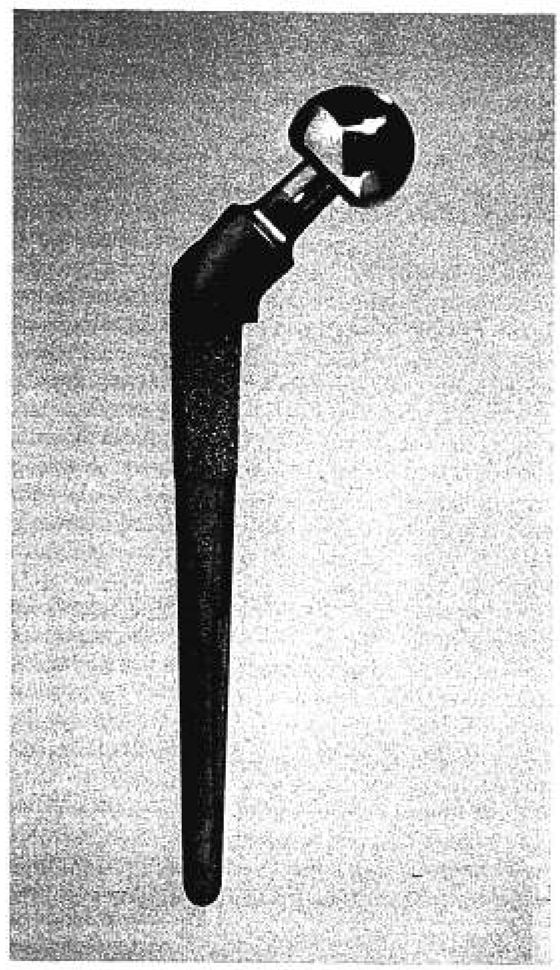


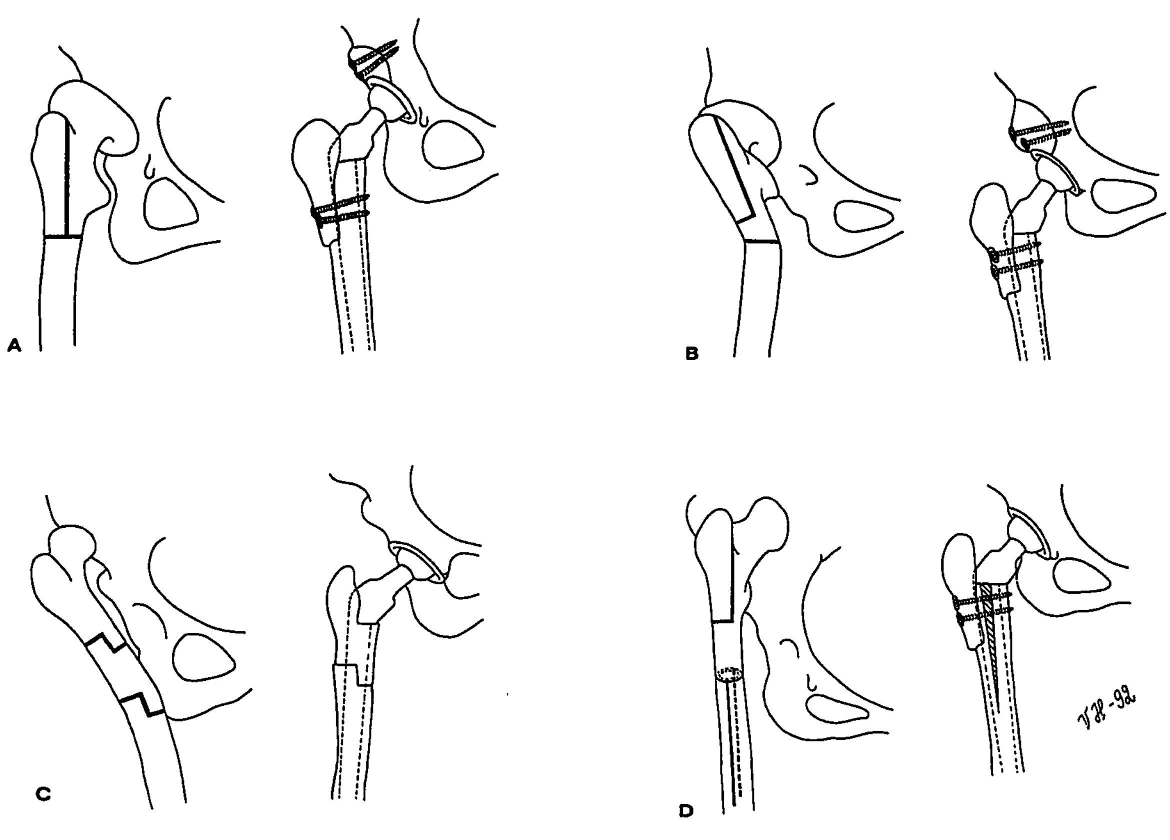
FIG. 1. The straight cementless 17-mm stem with a medium deep modular head. Sizes of the stem are available from 13 to 19 mm. The size is measured from below the collar. Maximum breath of the intramedullary part of the stem is 12 mm.

techniques used for the femur are presented in Figure 2. Posterolateral Moore exposure was used in most cases. Anterolateral approach, according to Hardinge,[9] with the patient in a lateral position, was preferred only in hips where low-seated Schanz osteotomy had previously been performed (Fig. 2C). The sciatic nerve was always identified.

Acetabulum in hips with total dislocation (Eftekhar Stage C and D) is severely hypoplastic. There was often a tepee-shaped small cotyloid cavity just big enough for a finger tip. The anterior wall was often missing. For orientation and evaluation of the bone stock, it was important to identify the proximal parts of the pubic and ischial bones. The new acetabulum was shaped close to the original acetabulum when possible. If the anteroposterior diameter was too small at this level, the cup had to be mounted more distally (Figs. 2B and 2C). As a rule, there is an anterolateral bony prominence close to the junction of the pubic and iliac bones, which offers reliable anterosuperior support, and the junction of the ischial bone to the ileum gives excellent posterosuperior support for the acetabular component; the superolateral rim between these is often defective and can be reinforced with a bone graft (Figs. 2A and 2B). In a few hips the pelvic bone was so thin that fixation of the cup into the remodelled shallow acetabulum is not reliable. In these cases the medial wall of the reamed acetabulum could be detached from the pelvic bone and pushed inward, taking care not to compromise its periosteal attachments. The lining cap between pelvic bone and the pushed medial wall was reinforced by cancellous bone.[14] Roof reinforcement was performed if needed.

Femoral Osteoplasty

When the acetabular component has been seated at the level of the real acetabulum or lower, shortening procedures of the femur are often inevitable to reduce the prosthesis. Shortening was per-

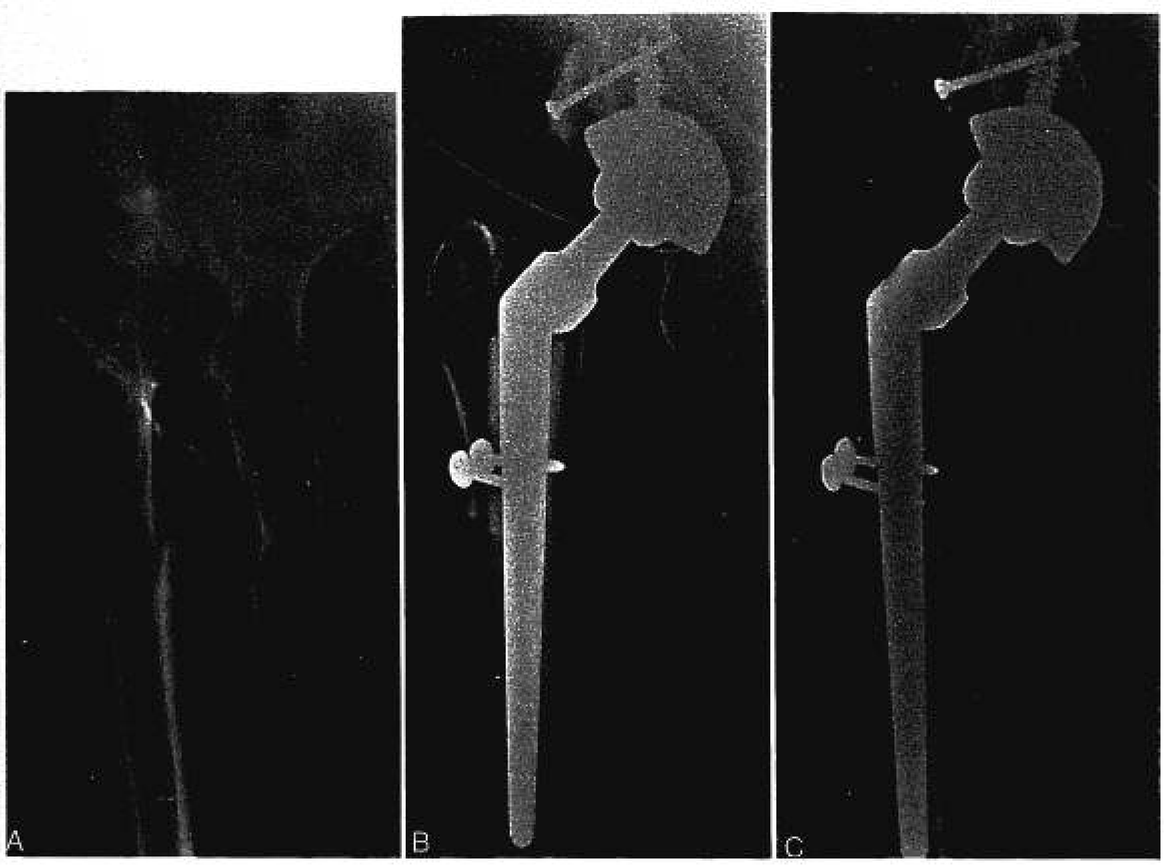


Figs. 2A–2D. Diagrams of the osteoplasties used for various deformities of the femur. (A) A proximal shortening osteotomy with distal advancement of the greater trochanter for high dislocations (31 hips). (B) Similar method as in Figure 1 applied for hips after high seated Schanz osteotomy (17 hips). (C) A segmental shortening with angular correction reserved for hips after low-seated Schanz osteotomy (six hips). (D) The femoral shaft is split if it is too narrow for the smallest stem (five hips).

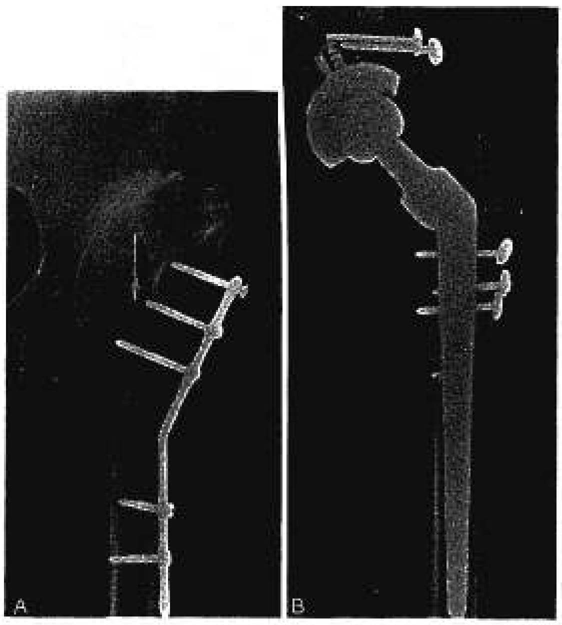
formed by an osteoplasty, which was chosen according to the shape of the proximal femur.

In the cases of high dislocation (Eftekhar Stage C and D) and tight subluxation (some cases of Stage B) a shortening osteoplasty of the femur and distal advancement of the greater trochanter was performed (Figs. 2A and 3). The proximal part of the vastus lateralis muscle was divided and the posterior half was released from the greater trochanter. The femur was divided at the metaphysis 7 to 9 cm distal to the apex of the greater trochanter. The medial half of the proximal femur was removed. The greater trochanter with the intact attachments of the gluteus medius and the anterior half of the vastus lateralis muscles was pulled anteriorly. After femoral osteotomy, there was excellent access to the lateral wall of the pelvis and acetabulum. The femoral diaphysis was reamed until 12 mm and rasped to appropriate size. The length of the femur was adjusted according to the preoperative planning and to the tightness of the soft tissues. After reduction of the prosthesis, the greater trochanter with its muscular attachments was advanced distally as far as possible to tighten the abductor muscles, and fixed with two to four screws, which were driven both anterior and posterior to the stem. This was performed with the hip in wide abduction, and often was aided by discission of the tight tendinous central part of the gluteus medius muscle. The posterior half of the vastus lateralis muscle was tightened and fixed to the greater trochanter, and the loosened anterior half of the muscle was duplicated. This type of osteoplasty is appropriate also for the femora after high-seated Schanz osteotomy (Figs. 2B and 4).

If the femoral shaft proved too narrow for the stem, it was split both anteriorly and posteriorly for 8 to 10 cm. Only then was the medullary canal prepared for the stem. The splits were filled with



FIGS. 3A–3C. (A) Preoperative radiograph of a high dislocation of the right hip (Eftekhar Stage D) in a 38-year-old man. (B) Immediate postoperative radiograph after a proximal shortening osteotomy with distal advancement of the greater trochanter. Functional lengthening of the leg was 3.5 cm as expected. (C) The same hip 3.5 years later with good clinical result and excellent abductor strength.



FIGS. 4A AND 4B. (A) Preoperative radiograph of the left hip in a 58-year-old woman with bilateral dislocation. The high-seated Schanz osteotomy had been performed 30 years earlier. (B) Radiograph taken two months after a shortening osteotomy with distal advancement of the greater trochanter. The stem was seated at the level of the Schanz osteotomy. Functional lengthening of the leg by only 2 cm was required.

cancellous bone, the posterior one from within, before the stem is inserted. The splits were fixed by the lagscrews used to secure the greater trochanter (Figs. 2D and 6).

In hips with unilateral low-seated Schanz osteotomy, metaphyseal segmental shortening and angular correction was performed to allow reduction (Figs. 2C and 5). A step method was used to stabilize the osteotomy against rotation. The amount of shortening was estimated in advance from radiographs and templates according to the expected amount of lengthening of the femur. Both the proximal and distal parts of the femur have to be reamed carefully to achieve accurate fitting of the prosthetic stem so that it functions as an intramedullary nail. The osteotomy ought to be on the level of porous coating of the stem to achieve more stability. By this method functional lengthening of the leg is possible up to 3 cm (Fig. 6) but hardly more, whereas the other osteoplasties allow functional lengthening up to 5 cm. This is the most demanding and time-consuming of these osteoplasties.

All osteoplasties were performed with minimal periosteal stripping to avoid devitalisation of the bone. Tight adductors were readily tenotomized. Excessive stretching of the sciatic nerve was carefully avoided.

The numbers of various osteoplasties of the femur are presented in Figure 2. No femoral osteoplasty was needed in eight cases. In all cases, a cementless Biomet CDH stem was used.

The position of the acetabular component was anatomical in 21 hips, in eight of which the defective acetabular roof was reinforced with autogenous bone. In 46 cases, the acetabular component was placed below the anatomic position, and in 28 of these hips reinforcement of the acetabular roof was performed. The self-tapping smooth-threaded cup was used in 50 hips, and the press-fit cups in 17 hips (13 Mallory-Head, four Universal; Biomet, Warsaw, Indiana).

As an acetabular component, a self-tapping smooth-threaded cup (TTAP/ST, Biomet, Warsaw, Indiana, USA) was generally used in the authors' hospital from 1986, especially for patients younger than 65 years. The first alarming signs of the loosening problem of that component were seen in the spring of 1989, and the authors changed to the press-fit porous-coated acetabular components (Mallory-Head and Universal). These components are even easier to insert than the threaded ones.

The mean duration of the operation was 195 minutes (range, 110–350). Preoperative bleeding averaged 1921 ml (range 450–6500).

POSTOPERATIVE MANAGEMENT

The day after surgery the patient was allowed to stand and take a few steps. The next day he began to walk, bearing partial weight and using sticks. If the abductors were very tight the patient was allowed to remain in bed a couple of days performing isometric exercises. Progressive flexion, extension, and abduction exercises were started, but abduction against resistance was allowed only after six to eight weeks. After this, progressive increase in weight-bearing was allowed as indicated by the radiographic consolidation of the osteoplasty, and abduction exercises were intensified. The ipsilateral stick was discarded eight weeks after the operation, but the contralateral one was used until the abductor muscles were strong enough to balance the pelvis and abolish limp, usually four to six months after operation.

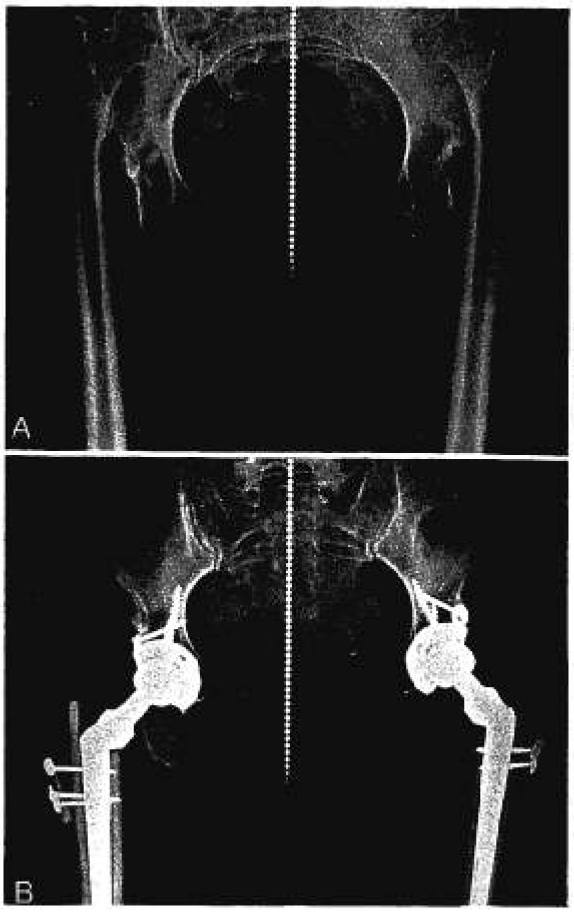
RESULTS

Pain was improved in every case. Mean pain score before operation was 17/40 (range,

FIGS. 5A–5C. (A) Radiograph of a low-seated Schanz osteotomy of the right hip in a 60-year-old woman. The patient had increasing pain in her hip and low back. (B) Postoperative radiograph after segmental shortening osteoplasty combined with angle correction. Functional lengthening of the leg was 3 cm. Note the low-located acetabular component. (C) The same hip one year later with good clinical result; Trendelenburg sign was negative.

0–20), after operation 38/40 (range, 35–40) in hips with stable components. The mean preoperative clinical Mayo Hip Score was 35/80 (range, 12–51), after operation, 66/80 (range, 48–80). All patients had limped before the arthroplasty, 53 (79%) of the hips having severe, and nine (13%) slight Trendelenburg sign. At the follow-up visit, the Trendelenburg sign was slight in five hips (7%), and negative in 62 hips (93%). Thirty-seven of the 60 patients (62%) needed walking aids before operation; four required crutches. After operation, three patients used a stick regularly and four occasionally. The mean total range of movement improved from 183° (range, 0–410) to 252° (range, 150–365).

The mean clinical leg-length discrepancy before operation was 34 mm (range, 0–80) and after operation 12 mm (range, 0–40). The radiographic true leg-length inequality before operation was 21 mm (range, 0–78) and after operation 29 mm (range, 0–80). Before operation, the affected side was shorter in 34 cases, longer in 30 cases, and the length was equal in three cases. After operation, the operated side was shorter in 57 cases and longer in ten cases. The radiographic functional leg-length inequality (the height difference between the ischial tuberosities) before



FIGS. 6A AND 6B. (A) Radiograph of an untreated bilateral high dislocation in a 51-year-old woman. She had increasing pain when walking. Involution atrophy of the hypoplastic femoral heads has occurred, and they have become rough and deformed. (B) Proximal shortening osteotomy with distal advancement of the greater trochanter has been performed on both sides. The femoral shaft was too narrow for the stem, and was split on both sides. Eight months after replacement of the left and two months after the right hip, functional lengthening of the leg was 3 cm on both sides.

operation was 26 mm (range, 0–85) and after operation 11 mm (range 0–82). Before operation, the ischial tuberosity of the affected side was on a lower level in 50 cases, on a higher level in 16 cases, and on a same level in one case. After operation, the ischial tuberosity of the affected side was on a lower level in 27 cases, on a higher level in 28 cases, and on the same level in 12 cases.

COMPLICATIONS

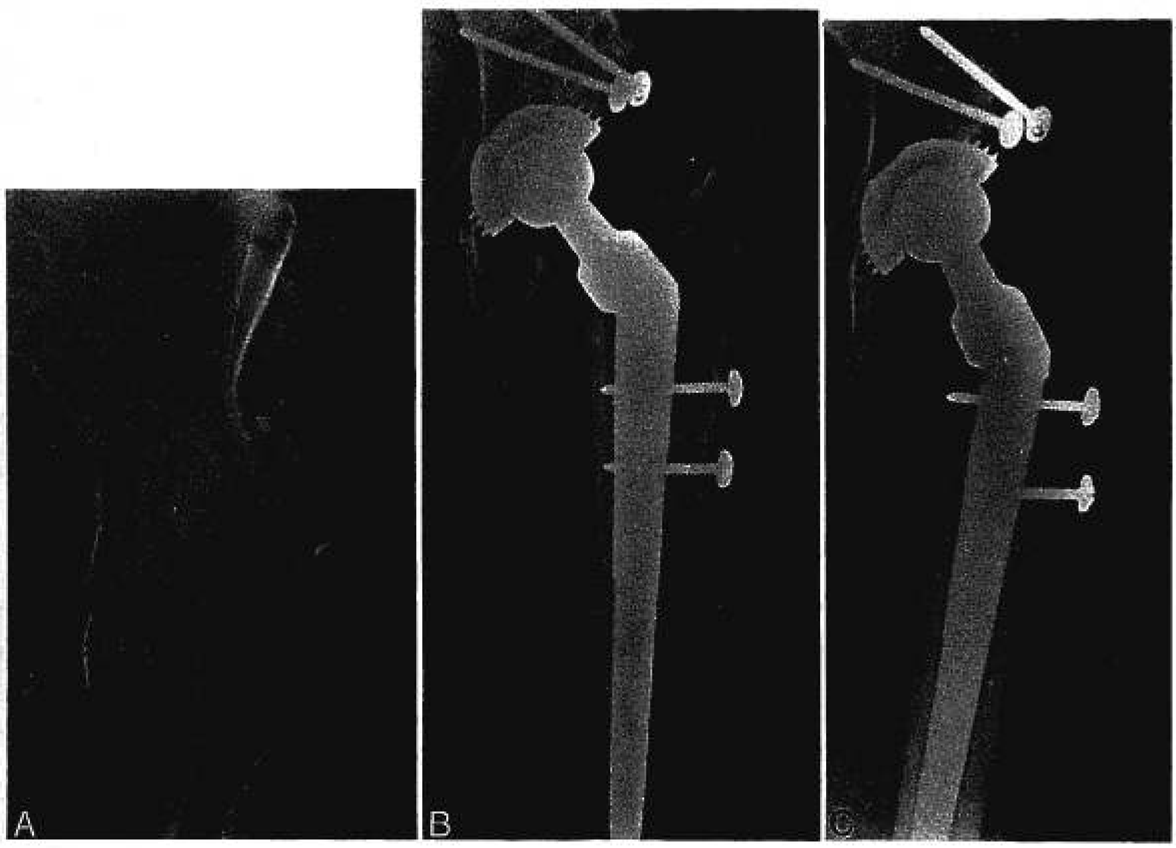
In five cases the proximal metaphysis of the femur was accidentally split, two of these being medial and fixed with the Parham band. All others were located anteriorly or posteriorly, and were fixed with the lagscrews used to secure the greater trochanter. No further treatment was required. One deep vein thrombosis occurred without pulmonary affections. There were no infections.

In two cases of segmental shortening and angle correction, the proximal part of the femur fractured two and four weeks after operation and was treated with a hookplate fixation and bone grafting. There was one late dislocation treated with closed reduction, without recurrence.

Late loosening of the smooth-threaded cup has occurred in 26 hips (52%), and 22 of these (44%) have already been revised. There are no complications associated with the 17 press-fit acetabular components. The femoral stem got loose in four hips two to three years after operation, and two of these have been revised (Fig. 7).

DISCUSSION

There are two major technical problems associated with the replacement surgery of severely dysplastic or dislocated hips. The acetabular component must be seated near the real hypoplastic cotyloid cavity or distal to it to get reliable fixation of the acetabular component and to achieve abductor strength strong enough to balance the pelvis.[4,5,7,10–12,18,20,27] Especially in hips with high dislocation, shortening procedures of the femur are inevitable to bring the prosthetic head low enough for reduction.[2,4,5,12,18,20,27] The authors solved this problem either by proximal shortening of the femur combined with distal advancement of the greater trochanter, or by



FIGS. 7A–7C. (A) Severe secondary osteoarthrosis of a subluxated hip (Eftekhar Stage B) in a 38-year-old woman. (B) Proximal shortening osteotomy with distal advancement of the greater trochanter has been performed, but the trochanter has been detached so far distally that the lateral support of the stem was deficient to give adequate rotational stability. (C) The stem remained unstable and has migrated 1.5 cm. Three of the four loosenings of the stem have ensued from the same technical error.

segmental metaphyseal shortening osteoplasty.[20] The former is a simple and safe procedure without risks of major complications. The detached greater trochanter must be big enough (7 to 9 cm long) for reliable cortical screw fixation. The straight stem is always mandatory in this procedure. The segmental shortening osteotomy was used in the former series with Lord's prosthesis in many congenitally dislocated hips when there was some femoral neck shape left.[20] The results were anatomic and fine in radiographs. The functional results, abductor strength and range of movements, were no better than the results of the former procedure, however. The segmental osteoplasty is laborious and time-consuming and there is considerable risk of fracturing the proximal fragment, and functional lengthening of the leg is limited to only 3 cm. The authors use this method only for unilateral hips after low-seated Schanz osteotomy. The straight stem is also proper in most of these hips. In a few cases the neck curve is so well developed that a stem with reduced neck curve is more appropriate (cementless head/neck stem, Biomet, Warsaw, Indiana). Rotational correction of the anteverted proximal femur is performed at the same time.

Primary complications with the straight stem were few, although the results present the learning curve of six different surgeons. Proximal splits occurred in five cases, only two of these needing additional fixation. Intentional splitting of the femur because of a very narrow shaft was necessary in five cases and they healed without complications. There were four late loosenings of the stem, two of them having been revised already. In three of these cases, the greater trochanter had been detached so far distally that lateral support and rotational stability of the stem was deficient (Fig. 7). The fourth of the loose stems was too small. The axial stability achieved by the collar instead of the oval wedge shape of the stem compromised rotational stability. This is the well-known disadvantage of the collared press-fit stems. Therefore the authors emphasize careful rasping and exact fitting of the stem. There were three complications concerning the greater trochanter: one fibrous union after trochanter transfer, and two dislocated fractures of the proximal metaphysis and trochanter after segmental shortening osteoplasty. These were successfully treated by hookplate fixation and bonegrafting.

The incidence of late loosening of the smooth-threaded cup was unacceptably high, being even higher than after replacement with Lord's threaded cup. In the authors' nation-wide register,[21] the survival curve of TTAP/ST-cup (1350 hips) decreases sharply after two and one half years; the same downward turn of Lord's curve (1410 hips) occurs after five and one half years. The limit of 80% survival is reached before five years by TTAP/ST-cup and just before eight years by Lord's cup. The authors abandoned the threaded cup and started to use porous-coated press-fit components in May 1989. Since that time they have had neither radiographic nor symptomatic loosenings. The hips revised with press-fit components are doing well, too. The groin and buttock pain disappeared and neither progressive radiolucencies nor migrations have been found. Engh *et al.* have reported similar experiences.[6] With an average follow-up period of 3.9 years, 21% of the patients with a smooth-threaded cup showed radiographic signs of instability, and 25% had clinical symptoms. On the contrary, none of the patients with porous surfaced press-fit components had signs of instability during an average follow-up period of 4.8 years. Silber and Engh[23] treated 19 dysplastic hips. With three-year follow-up, all the porous-coated acetabular components remained stable, but only one of the six smooth-threaded components maintained stability. Many other authors have reported similar unacceptable results with smooth-threaded acetabular components.[1,13,19,22,24–26]

Hip abductor muscles strengthened in every case. Before operation, there was a severe Trendelenburg sign in 53 hips, and a slight one in nine hips. Many of the patients with slight or negative Trendelenburg sign were cases after Schanz osteotomy with amply medialized femoral shaft and very weak abductor muscles. After operation, the abductors strengthened enough to abolish the Trendelenburg sign in 62 hips, whereas slight weakness remained in five hips. Before operation, 62% of the patients needed walking aids, some required two crutches; after operation, 12% of them used one stick, most of them occasionally only, and because of other joint affections. The authors often see increasing Duchenne gait with negative Trendelenburg sign associated with asymptomatic instability of the cup. As a rule this phenomenon disappears after revision.

Secondary valgus deformity of the ipsilateral knee was often conjoined to the dislocated hips, in particular to those after Schanz osteotomy. This was aggravated by the lateralizing effect of the femoral shaft associated with hip replacement. According to the degenerative changes of the lateral compartment, supracondylar dome osteotomy of the femur or arthroplasty of the knee, either unicompartmental or total, was performed.

Leg-length inequality is one of the main problems in replacement of dysplastic hips, and various methods have been presented to restore equal leg length.[5,7,10,18,27] The mere anatomic length of the lower extremities is misleading as long as the position of the acetabulum is not taken into account in the assessment of functional leg-length disparity.[15,16] The functional leg-length inequality (the amount of compensation of the leg-length inequality required to obtain balanced attitude of the pelvis) should therefore be determined, instead of anatomic or true leg length inequality.[15,16] In dysplastic hips, the hip joint is situated above the anatomic area. Hence it has been thought that the leg will be overlengthened if the acetabular component is placed in an anatomic position and the femur is advanced distally.[4] On the contrary, it has been suggested that if the femur is shortened during arthroplasty, the leg may get too short.[10] The true leg length on the side to be replaced has been shown to be longer as often as shorter in cases with dysplastic hips,[15] which was also true in the current series. Accordingly, depending on the amount of true leg length disparity, the leg would have become functionally longer in many, but not in all, cases if shortening osteotomy of the femur had not been performed. After operation, the true leg length on the operated side was often shorter than on the contralateral side, but good correction of the functional leg-length inequality was obtained. This agrees with the authors' previous study of leg-length inequality in dysplastic hips.[15]

Functional increase in leg length of 2 to 5 cm was easy to achieve by the methods used; more lengthening is limited by tight soft tissues, especially by the sciatic nerve. It is often difficult to evaluate the optimal amount of correction. The younger the patient, the more the authors try to achieve equal length, especially if the patient has compensated the inequality by elevated footwear. The middle-aged and elderly patients with fixed degenerative changes in the low back must be carefully tested before operation with various elevations. There were no neurological complications in this series. This danger exists, however, especially in cases with adhesions after old tuberculous coxitis.

In general, these patients were satisfied with the relief of pain, improvement of gait and walking ability. These improvements made them accept even the unexpected problems with the threaded acetabular component, especially as the good primary result was restored as a rule after cup revision. The incidence of the primary complications was low and essentially reduced when compared with the former series with Lord's prosthesis, this being in part because of the straight stem, and in part because of increased experience and advances in techniques.[20]

Although the straight stem used is functioning well, one drawback remains to be improved. Rasping must be very exact and careful to synchronize rotational stability gained by the oval 3° wedge shape stem and axial stability confirmed by the collar. It is far too easy to produce proximal splits when inserting the stem. Therefore a collarless stem is under construction.

Replacement surgery of these problematic hips is challenging and demanding, but it is highly rewarding to see these crippled people gain normal or an impressively improved gait and walking ability. Still indications for this type of surgery must be thoroughly considered because of the unsolved problem of late loosening associated with the wear debris. The patient must be well motivated for the surgery and the strenuous postoperative exercise program.

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