Acta orthop. Scandinav. *39*, 518–538, 1968

From the Orthopaedic Department, Kyoto University, School of Medicine, Kyoto, Japan (Head: Tetsuo Ito, M.D.), and Orthopaedic Department, Hiroshima University, School of Medicine, Hiroshima, Japan.

OPERATIVE TREATMENT OF OSTEOARTHRITIS OF THE DYSPLASTIC HIP JOINT

By

TETSUO ITO, MOTOO YOKOSAKI & MASAKI NAKAMASU

Received 27.ii.67

McMurray (1935) advocated his oblique intertrochanteric osteotomy with medial displacement of the distal fragment for osteoarthritis of the hip. In 1950 *Pauwels* introduced varus osteotomy without displacement, an operation which has been used chiefly on young adults with painful dysplastic hips. His procedure is based on the principle of an increase in weight-transmitting areas of the articular surfaces. With his method he demonstrated that osteoarthritic hip joints have a remarkable regenerative power, regardless of the stage of the disease or the age of the patient. *Voss*' temporary hanging hip operation has also secured a place in the treatment of degenerative hip disease. It was proved that his operation also relieves pain and promotes regeneration of the affected joint. It is frequently used in patients too old to tolerate such major operations as arthrodesis and osteotomy. Furthermore, in cases with medial ostephyte formation. *Pauwels* tried valgus osteotomy combined with release of the muscles about the hip to increase the weight-transmitting areas of the articular surfaces. In addition, he theoretically demonstrated the following three factors, which improve the degenerative changes in the joint.

1. Reduction of intermittent pressure in the hip during walking.
2. Reduction of pressure caused by muscle tension.
3. Increase in the size of the areas of the joint surfaces on which these forces act.

Furthermore, *Pauwels* demonstrated the mechanism of osteotomies, which he compared with a release operation in overcoming vicious muscle pull at the hip (Figures 1 and 2). In his opinion, the varus

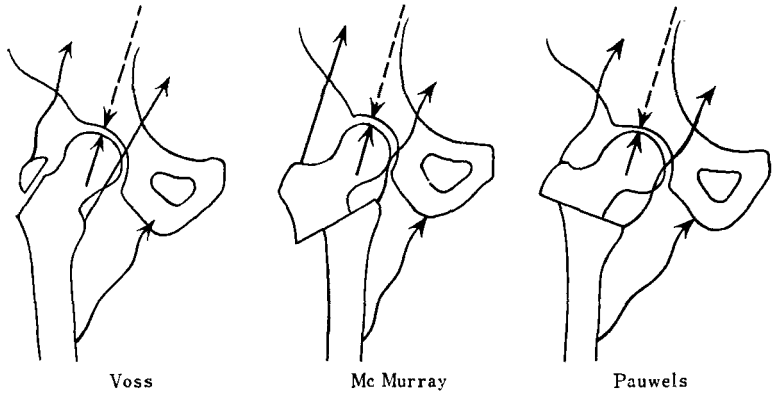

Figure 1. Drawings adopted from Pauwels illustrate the muscles that are relaxed to relieve pressure on the hip by the Voss' original hanging-hip operation, by the McMurray's osteotomy, and by the Pauwels' varus osteotomy.

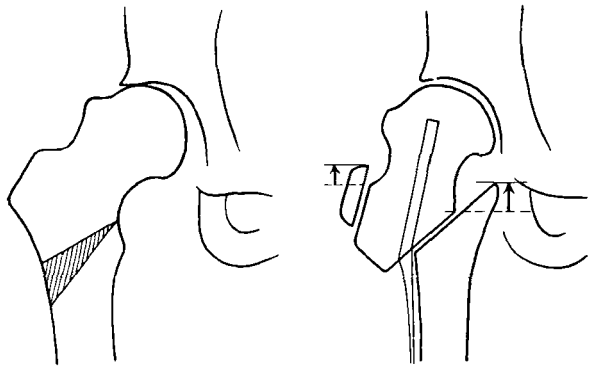

Figure 2. Pauwells' valgus osteotomy accompanied by the muscle release operation.

osteotomy meets three demands for improvement of the disease and valgus osteotomy combined with release operation meets two demands. *McMurray*'s displacement osteotomy also reduces the load acting on the joint, like *Voss*' hanging hip procedure.

An incongruity between the articular surfaces is one important etiological factor of osteoarthritis of the hip. It may be due to dysplasia of the femoral head or acetabulum or both, with or without coexisting subluxation of the joint. It may be acquired, for instance, as a sequela of coxa plana, and it may also be traumatic. Another group is made up of senile osteoarthritis, whose pathogenesis is not yet properly

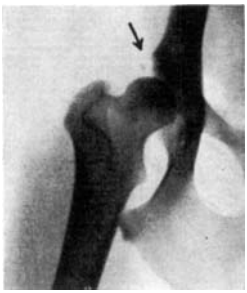

Figure 3. Roentgenogram showing resection of the outer edge of the acetabulum in a dog.

understood. Follow-up studies of the clinical process in a large series of osteoarthritis of the hip suggest that in Japan the vast majority of cases is caused by acetabular dysplasia. We therefore undertook an experimental study of the biomechanism responsible for the development of osteoarthritis of the hip in dogs, in which the superior outer edge of the acetabulum was resected. On the basis of the results of clinical studies reported by many authors mentioned above and observations made in our clinical and experimental studies, we were able to lay down basic principles of treatment of osteoarthritis of the hip with incongruity. Furthermore, on the basis of these principles, various operative procedures were performed in 50 cases of osteoarthritis of the hip. The results of our studies are reported below.

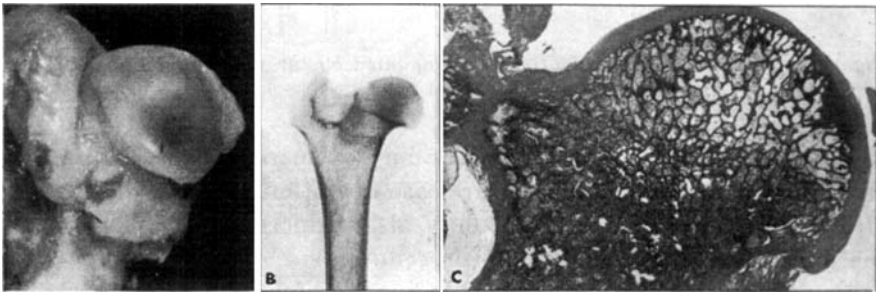

Figure 4. Pathological changes in the femoral head in a dog four months after resection of the outer edge of the acetabulum. The mushroom-shaped femoral head is seen in the gross specimen (A), roentgenogram (B) and histological section (C). The histological picture (C), shows slight abrasion of the central part of the articular cartilage and replacement of the red marrow with fatty tissue accompanied by formation of osteophyte around the head.

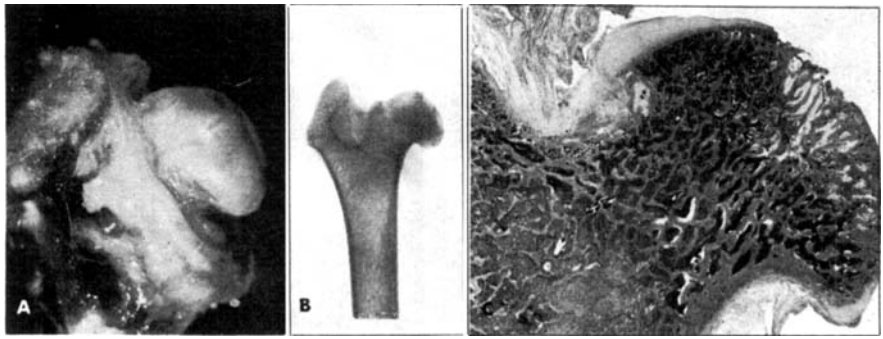

Figure 5. Pathological changes in the femoral head in a dog five months after resection of the outer edge of the acetabulum. A mushroom-shaped femoral head is seen in the gross specimen (A), roentgenogram (B) and histological section (C). The histological picture shows almost complete loss of the articular cartilage, destruction of the bony trabeculae at the top of the head accompanied by thickening of the remaining trabeculae and formation of a large osteophyte around the head (C). In the lateral non-pressure part of the head there is a region with thin trabeculae seen as a localized radio-translucent area in the roentgenogram (B).

Experimental and Clinical Studies on the Development of Osteoarthritis in the Hip with a Defect of the Outer Superior Acetabular Roof

When the outer superior edge of the acetabulum was resected in adult dogs (Figure 3), degenerative arthritic changes developed within five to six months after operation. The results of this experiment are summarized as follows:

1. Abrasion of the central localized part of the articular surfaces due to abnormal friction was the first pathological change which appeared in the course of the experiment (Figures 4-A, 5-A, and 6-A).

2. With time, osteophytes formed around the femoral head, which then migrated from the center of the acetabulum (Figures 4 and 5).

3. On histological examination of the femoral head within one to two months after operation, almost all the animals showed destruction or loss of the central small localized articular surface and thinning or loss of the trabeculae in the upper part accompanied by replacement of red marrow with fatty tissue (Figure 4-C). These pathological changes were followed by reactive proliferation of the cartilage cells in the articular cartilage and reactive thickening of the remaining trabeculae and new bone formation around the head (Figure 5-C). In typical cases, five to six months after operation, marked thinning of the trabeculae or the formation of cysts was found in the lateral part

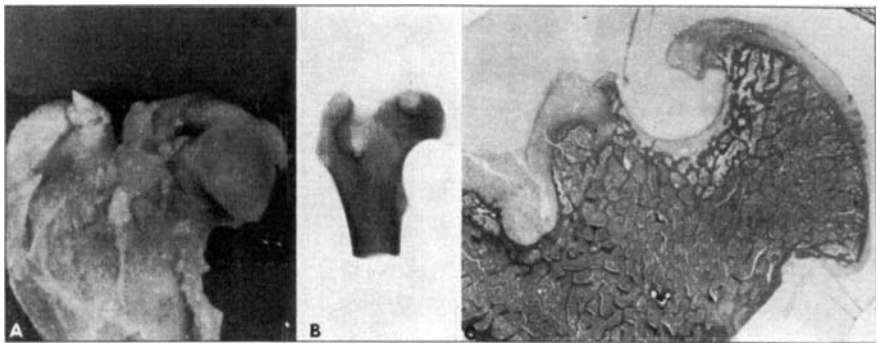

Figure 6. Pathological changes in the femoral head in a dog six months after resection of the outer edge of the acetabulum. Formation of a large cyst is found in the lateral part of the femoral head which is subject to least pressure.

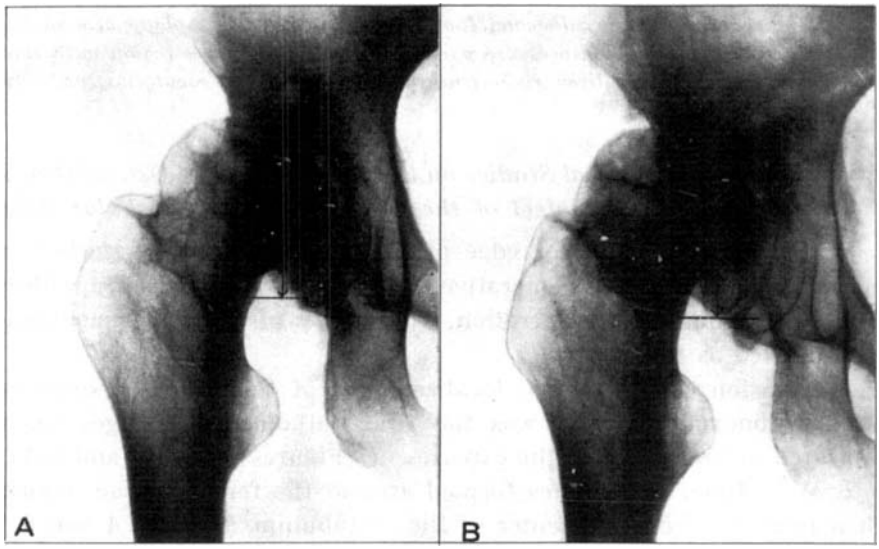

Figure 7. Roentgenograms showing rapid upward migration of the femoral head in the dysplastic hip with osteoarthritis. Figure 7-A in November, 1964, Figure 7-B May, 1965. The upward migration of the femoral head was accompanied by an enlargement of the medial osteophyte, indicated by arrows.

of the head which was subjected to least pressure (Figures 5-C and 6-C). Similar pathological findings are also often made in human osteoarthritis of the hip. Two roentgenograms made at an interval of six months in a case of osteoarthritis of the hip with acetabular dysplasia are reproduced in Figures 7 A and B. Figure 7-A shows acetabular

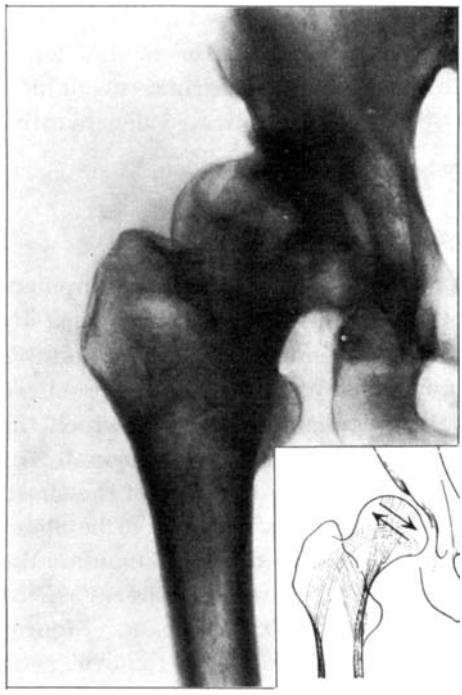

Figure 8. Dysplastic hip with degenerative arthritis. Several cysts are arranged in the oblique equatorial plane of the femoral head where shearing stress is supposed to act.

dysplasia, narrowing of the cartilage space and slight upward migration of the femoral head with formation of lateral cysts and a small medial osteophyte. The roentgenogram (Figure 7-B) made six months later, revealed rapid progress of upward migration of the femoral head followed by enlargement of the medial osteophyte. Figure 8 shows a moderately advanced case of osteoarthritis of the right hip. In this figure, the mushroom-shaped femoral head contains several cysts arranged in the oblique equatorial plane. These findings suggest that a shearing stress, as indicated by arrows, continuously acts on the medial longitudinal weight-bearing trabeculae in the femoral head, resulting in their gradual destruction followed by reactive formation of osteophytes around the femoral head and upward migration of the femoral head. In all cases with acetabular dysplasia, pressure on the femoral head caused by muscle tension is transmitted concentrically to the small localized contact area of the femoral articular surface and may cause a continuous shearing stress on the medial longitudinal trabeculae of the femoral head, resulting in their destruction. Moreover, during walking, an instability of the hip joint causes abnormal

friction between the two small articular surfaces which may exert an extremely strong intermittent shearing stress on the medial longitudinal trabeculae in the femoral head. All these abnormal mechanical factors may cooperate in the causation of the complicated degenerative changes in the hip joint.

Trabecular Architecture of the Upper End of the Femur

The results of experimental and clinical studies on the development of osteoarthritis of the hip prompted the authors to attempt a study on the trabecular architecture of the upper end of the femur. For this study, thirty specimens of the normal human femur were sliced parallel in the frontal plane. In these specimens, the angle, which the medial longitudinal weight-bearing trabecula, passing through the center of the femoral head, forms with the longitudinal axis of the shaft, was measured roentgenologically (Figure 9). It was found to be about 22°. Further, photoelastic experiments were carried out to elucidate the function of the transverse trabeculae arising from the lateral cortex below the greater trochanter and running to the femoral head (Figures 10-A and B). The tensile force in the upper part of the femoral neck induced by a vertical load on the femoral head, as indicated by the arrow in Figure 10-A, is eliminated by a load acting on the greater trochanter in the direction of the gluteal muscle, which is less than one-half of the load on the femoral head, as shown in Figure 10-B. In

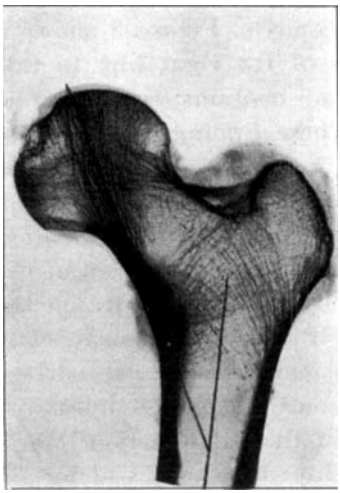

Figure 9. Roentgenogram showing the trabecular architecture of the upper end of the femur. The medial longitudinal trabeculae which bear the body weight form an angle of approximately 22 degrees with the longitudinal axis of the shaft.

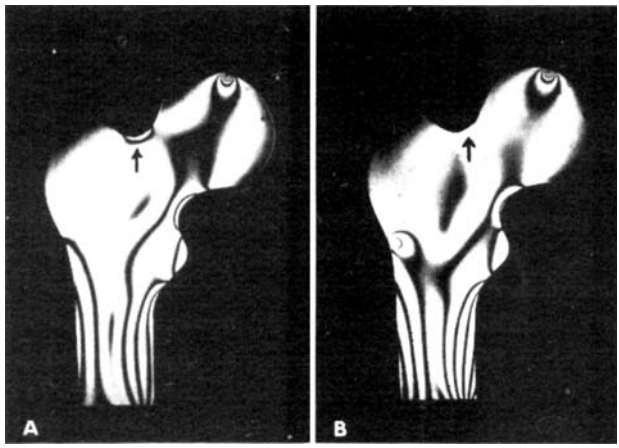

Figure 10. Photoelastic study on the mechanical stress induced by loads acting on the upper part of the femur. A tensile force at the upper part of the femoral neck induced by a vertical load acting on the femoral head, as indicated by the arrow in Figure 10-A, is eliminated by a load acting on the greater trochanter in the direction of the gluteal muscles which is less than one-half of the load on the femoral head, as shown in Figure 10-B.

the normal hip, the pressure of more than one-half of the load on the femoral head is thought to act on the greater trochanter in the direction of the gluteal muscle while standing and walking. It was proved by these photoelastic experiments that the transverse trabeculae also bear the transverse pressure produced by the abductor muscles, rotator muscles, tensor fasciae latae muscle, and also adductor muscles, which presses the femoral head against the acetabulum. From these facts, it is evident that the trabecular architecture of the upper end of the femur is also constructed on the basis of the following general principles of bone formation. The line of the bony trabeculae corresponds to the line of maximal pressure. Further, the trabeculae are thickest and most closely packed where the stress is greatest. The medial longitudinal trabeculae are thickest and most numerous and bear the greater part of the load on the joint. On the other hand, these long trabeculae are thought to offer the least resistance to shearing stress. It would therefore appear that in the hip with acetabular dysplasia the articular surfaces are worn down by friction and the medial longitudinal trabeculae are broken by shearing stress, resulting in destructive changes combined with reactive new bone formation around the femoral head and upward migration of the femoral head.

Principles of Operative Treatment for Osteoarthritis of the Hip with Incongruity between the Articular Surfaces

On theoretical grounds the results of the studies mentioned above warrant the following principles of operation for osteoarthritis of the hip secondary to acetabular dysplasia (Figures 11-A, B, C, and D).

1. In early osteoarthritis of the hip with marked acetabular dysplasia, in which the articular cartilage is well preserved, the affected joint is reconstructed into a mechanically stable condition by a shelf operation combined with a muscle release operation around the hip (Figures 11-A and B). In this case, innominate osteotomy may also be indicated on the basis of the same principle.

2. In cases with acetabular dysplasia and deformities of the femoral neck or upward migration of the femoral head from the center of the acetabulum combined with formation of medial osteophyte, the affected joint is reconstructed into the mechanically stable condition by combination of the shelf operation, varisation or valgisation of the femoral neck and medial displacement of the shaft (Figures 11-C and D). Parti-

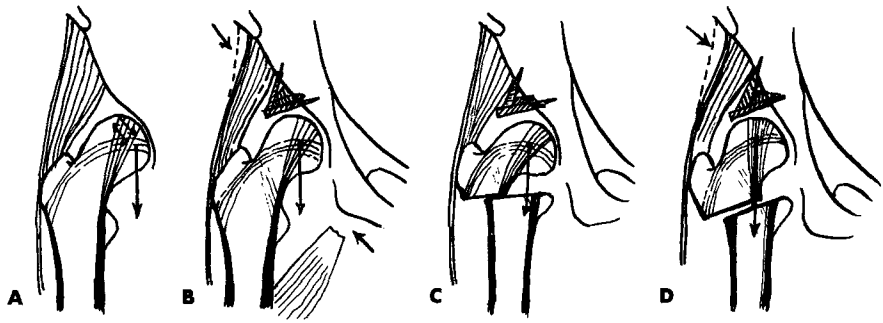

Figure 11. Diagrams showing principles of operative procedures for osteoarthritis of the hip secondary to acetabular dysplasia. In the hip with acetabular dysplasia, a load on the femoral haed is transmitted through a point medial to the center of femoral head. The small localized articular surfaces are subjected to a strong friction and the medial longitudinal trabeculae to a shearing stress (A). By shelf operation, these abnormal mechanical stresses are eliminated and the weight-transmitting areas of the articular surfaces increase in size. Moreover, the joint is decompressed by release of the muscles around the hip (B). Furthermore, as shown in C and D, the joint is reconstructed into the mechanically stable condition by various combinations of the shelf operation, varisation (C) or valgisation (D) of the femoral neck, medial displacement of the shaft, and release of the muscles about the hip. Particularly, by valgisation of the femoral neck, the medial longitudinal trabeculae are made erect, resulting in elimination of the shearing stress acting on them.

cularly, as seen in Figure 11-D, when the femoral neck is placed in a valgus position by osteotomy, the medial longitudinal trabeculae are made erect and, in consequence, they are completely released from the shearing stress. This procedure should be followed by a muscle release procedure to reduce the excessive pressure on the joint. Bone grafting in a large cyst promotes repair.

Technique of the Shelf Operation and Release of the Muscle about the Hip

The shelf operation should be performed with an exact technique. The Smith-Petersen anterior iliofemoral skin incision is usually used. The attachments of the gluteus medius and minimus muscle and tensor fasciae latae muscle are severed from the iliac crest and the gluteal muscles are subperiosteally stripped from the external surface of the ilium. The reflected tendon of the rectus femoris muscle is also dissected. Then the joint capsule is opened and the site where the shelf is to be created is determined under direct vision. Next, two bone plates and several small bone chips are taken from the outer table of the ilium. A bone plate, concave in shape and of size adequate to cover the portion of the femoral head which projects beyond the acetabulum, is inserted deeply into the acetabular rim in a semicircular line conforming to the natural curve of the acetabulum. Then the second bone plate is bridged between the first bone plate and the outer table of the ilium. Several bone chips are placed in the triangular space surrounded by the two bone plates and the ilium. The abductor muscles and tensor fasciae latae muscle are reattached to the ilium in a relaxed state. Subsequently, open adductor tenotomy is carried out. No plaster cast is applied. After operation, skin traction of the involved leg, up to four kilograms, is maintained for four weeks. Thereafter, the patient is encouraged to perform exercises of the affected limb and is allowed up on crutches.

MATERIALS

Since 1959, 50 osteoarthritic hips of 48 patients (45 females and 3 males), aged 19 to 57 years (mean 35), have been surgically treated in accordance with the principles described in the foregoing. In this series, the shelf operation combined with release of the muscles about the hip was performed in 38 hips and various combinations of shelf operation, varisation or valgisation of the femoral neck and medial displacement of the femoral shaft by intertrochanteric osteotomy and release of the muscles about the hip were carried out in 12 hips.

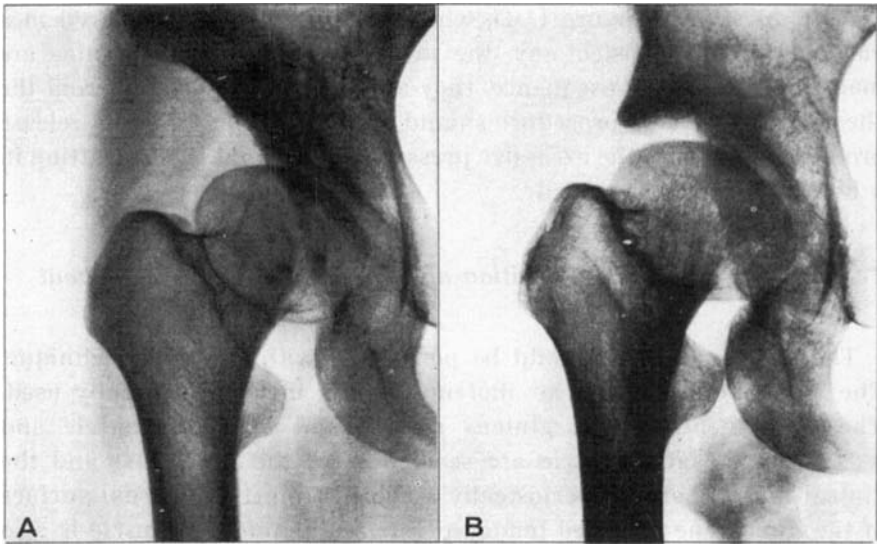

Figure 12. Case 1. A, an early stage of osteoarthritis of the hip with formation of cyst in the dysplastic acetabular roof. B, three years after the shelf operation combined with release of the muscles around the hip.

RESULTS

The patients were followed up for two to seven years (average: three and a half years). So far good results have been obtained in all cases. In most cases, pain of the affected hip disappeared two to six months after operation. However, limp due to weakness of the muscles about the hip persisted for more than six months after the operation. Roentgenographically, the shelf created was replaced by new bone within six months after operation. The degenerative changes in the affected joint were gradually repaired in the course of one to two years. In advanced cases in which the shelf operation was carried out in combination with medial displacement of the femoral shaft and varisation or valgisation of the femoral neck, numerous thickened vertical longitudinal trabeculae were formed in the femoral head, and the cartilage space also increased in width. The range of motion of the involved hip decreased to some degree in some cases, but this was of little concern as the patients were relieved of pain.

CASE REPORT

1. Shelf operation combined with release of the muscles about the hip.

Case 1: H.Y., a woman, 29 years old, with progressive pain of the left hip since

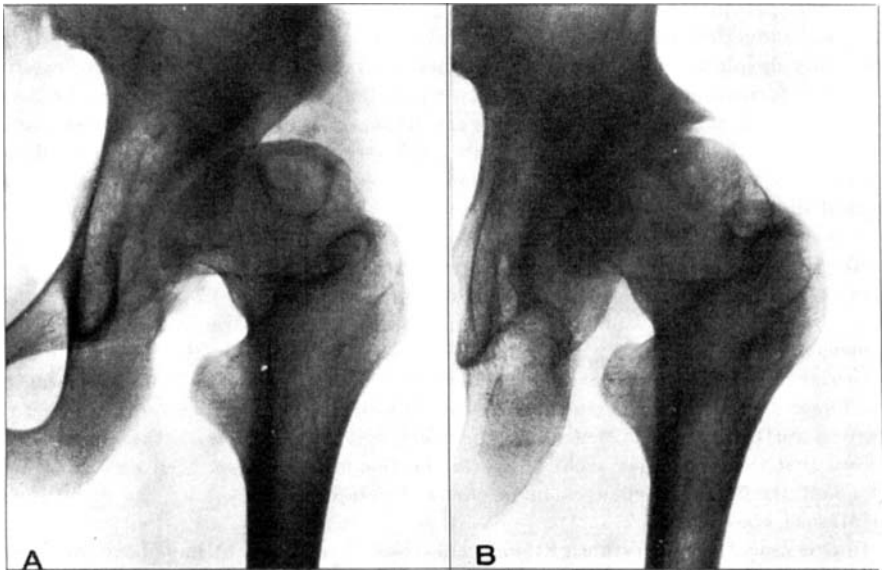

Figure 13. Case 2. A, osteoarthritis of the dysplastic hip with deformity of the femoral head and cyst in its lateral part. B, three years after the shelf operation combined with release of the muscles around the hip.

she was the age of 24. There was no limitation of motion. X-ray showed marked acetabular dysplasia with formation of a cyst (Figure 12-A), but the cartilage space was well preserved. The shelf operation was performed with release of the muscles about the hip followed by skin traction of the affected leg for four weeks. Six months after operation the hip was painless and six months later the limp also disappeared. Roentgenograms made four years after operation showed that the shelf created at the proper site was organized, well adapted to, and supported, the femoral head (Figure 12-B).

Case 2: F.K., a boy, 19 years old, with severe pain in the right hip for six months. He walked poorly with a stick. Examination revealed no limitation of hip motion. Roentgenograms showed a marked acetabular dysplasia and a mushroom-shaped deformity of the femoral head with a cyst in its outer non-weight-bearing portion. However, there was no narrowing of the cartilage space (Figure 12-A). The shelf operation was performed in combination with release of the muscles about the hip followed by skin traction of the involved leg for four weeks. One year after operation, the patient was completely free from pain and weakness of the hip also disappeared. Roentgenograms made three years after operation revealed that the shelf was incorporated and well adapted to the femoral head. The cyst had almost completely disappeared (Figure 13-B).

2. Combination of shelf operation, osteotomy, and muscle release operation.

(i) Combination of shelf operation, varisation of the femoral neck, and medial displacement of the shaft.

Case 3: N.S., a woman, aged 50 years. Progressive pain in the right hip had begun

two years previously. Mobility of right hip: flexion to 90 degrees, abduction to 10 degrees, adduction to 20 degrees and rotation zero. Roentgenograms showed a markedly dysplastic acetabulum, an outward migration of the femoral head, extensive cyst formation, and a slight narrowing of the cartilage space (Figure 14). As may be seen in this figure, several cysts are arranged in the oblique equatorial plane in the femoral head, along which a shearing stress is thought to act. The shelf operation was carried out in combination with varisation of the femoral neck and medial displacement of the shaft by osteotomy. A long hip spica cast was applied and was worn for two months. Six months after operation, the patient was relieved from pain and, moreover, weakness of the hip had also disappeared. There was no limitation of the hip motion. As seen in the roentgenogram (Figure 14-B) made seven years after operation, the right hip was nicely reconstructed, resulting in a remarkable restoration of the degenerative changes in both the bone and the articular cartilage. Numerous thickened vertical longitudinal trabeculae formed in the femoral head during these seven years. This suggests that a load on the femoral head is vertically transmitted along the longitudinal trabeculae to the shaft. This shows that the trabecular architecture in the femoral head had been reconstructed to adapt itself to the changes in mechanical condition caused by the operations mentioned above.

In this case, the restoration of the degenerative changes might have been obtained by varus osteotomy alone, valgus osteotomy combined with release of the muscles alone or also by oblique displacement osteotomy alone.

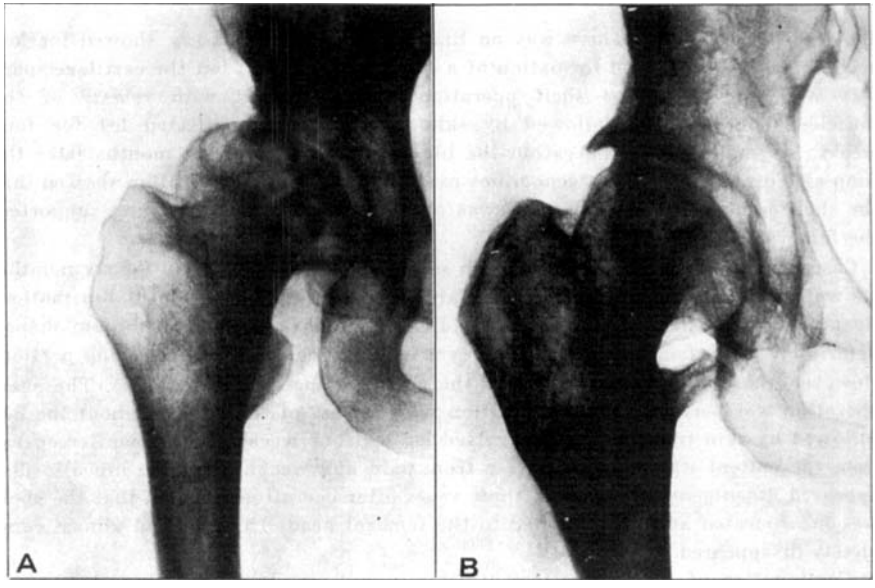

Figure 14. Case 3. A, ostearthritis of the dysplastic hip with several cysts arranged in the oblique equatorial plane of the femoral head. B, seven years after the reconstructive operation and medial displacement of the femoral shaft.

Figure 15. Case 4. A, an osteoarthritic hip with marked acetabular dysplasia and varus-anteversion deformity of the femoral neck. B, five years after combined operations of shelf operation, valgisation and derotation of the femoral neck, medial displacement of the shaft and muscle release operation.

(ii) Combination of the shelf operation, valgisation of the femoral neck and medial displacement of the shaft by osteotomy and release of the muscles around the hip.

Case 4: N.I., a woman, 20 years old, with dull pain in the left hip. There was no limitation of the hip motion. Roentgenograms revealed a marked dysplasia of the acetabular roof and an extreme varus-anteversion deformity of the femoral neck. However, no narrowing of the cartilage space was found (Figure 15). The shelf operation was carried out in combination with valgisation and derotation of the femoral neck and medial displacement of the shaft by intertrochanteric osteotomy. Tenotomy of the adductor muscles was not performed, because they were relaxed by medial displacement of the shaft. However, the abductor muscles were released, because they were stretched by valgisation of the femoral neck. The limb was immobilized in a long hip spica cast for two months. The patient was relieved from pain and weakness of the hip disappeared six months after operation. Roentgenograms made five years after operation revealed that the affected hip was reconstructed into the mechanically stable condition (Figure 15). As seen in this figure, the longitudinal trabeculae in the femoral head are thick, compact, and radiated proximately from the calcar femorale of the femoral neck in a fan-like fashion. If it is indeed true that form follows function, this region morphologically suggests that a load placed superiorly on the femoral head is transmitted concentrically to the calcar femorale of the femoral neck. This fact was also proved by a photoelastic

study (Figure 16). Therefore, the longitudinal trabeculae in the femoral head are completely released from the shearing stress.

Case 5: C.T., a woman, 57 years old, had had pain in the right hip for five years. It became progressively worse in degree and duration. Right hip motions were flexion to 60 degrees, abduction to 15 degrees, adduction to 15 degrees and rotation zero. Roentgenography showed a marked acetabular dysplasia, calcification of the joint capsule covering the lateral part of the femoral head, narrow cartilage space, and mushroom-shaped deformity of the femoral head with a medial osteophyte and a large cyst in the lateral part (Figure 17). In this case, combined operations composed of the shelf operation, bone grafting in the cyst, valgisation of the femoral neck and medial displacement of the shaft by intertrochanteric osteotomy, and release of the abductor muscles were carried out. A long hip spica cast was applied and was worn for two months. She was relieved from pain four months after operation. Weakness of the hip also diseappeared five months later. Roentgenograms made four years after operation showed a marked restoration of the degenerated areas (Figure 17-B. As may be seen in this figure, the shelf created united with the calcified joint capsule and adapted itself to the femoral head. The cyst in the femoral head subsided and cartilage space increased in width.

Case 6: M.M., a woman, 51 years old, has had increasing pain in the right hip for ten years. She walked poorly with a stick. Right hip: flexion to 85 degrees, abduction to 10 degrees, adduction to 20 degrees, and rotation zero. Roentgenography showed a mushroom-shaped deformity of the femoral head with its outward migration from the center of the acetabulum, accompanied by formation of a large medial osteophyte and a large cyst in the lateral non-pressure portion of the head. There was almost complete obliteration of the cartilage space (Figure 18-A). In this case,

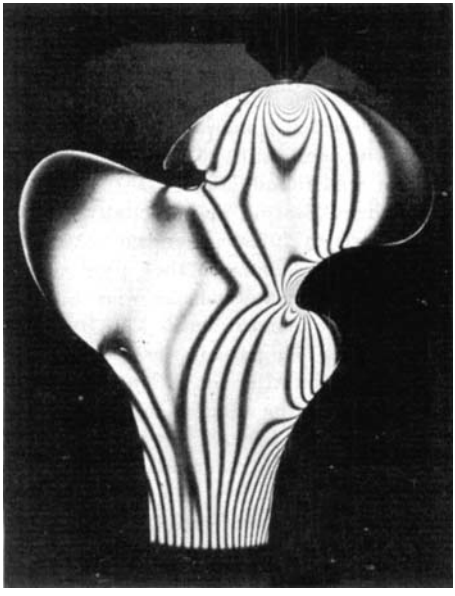

Figure 16. Case 4. Photoelastic study shows that a vertical load acting on the femoral head is transmitted concentrically to the calcar femorale of the femoral neck.

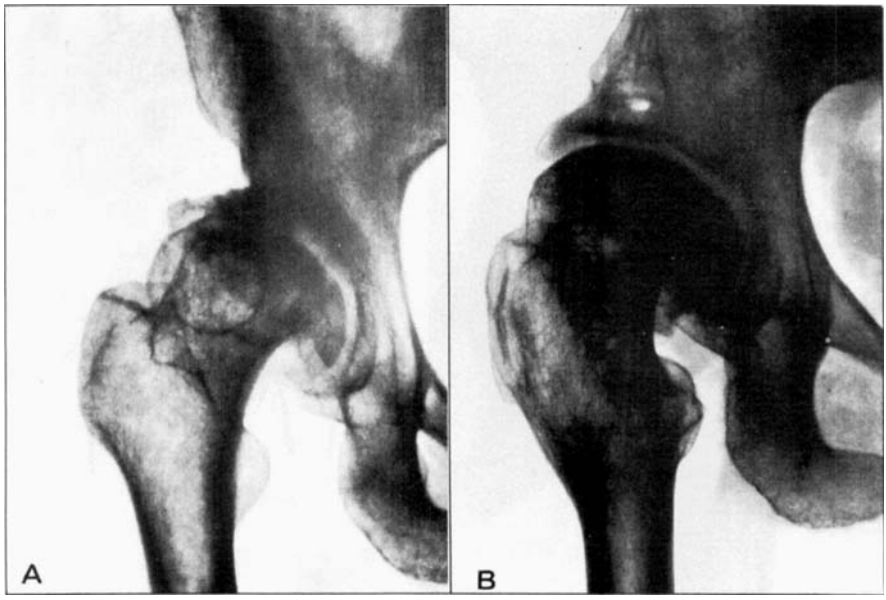

Figure 17. Case 5. A, advanced osteoarthritic hip with acetabular dysplasia, calcification of the joint capsule covering the lateral part of the femoral head, mushroom-shaped femoral head having a large cyst and medial osteophyte, and narrowing of the cartilage space. B, four years after combined operations i.e. shelf operation, bone grafting in the cyst, valgisation of the femoral neck, medial displacement of the shaft, and release of the muscles.

combined operations composed of the shelf operation, bone grafting in the cyst, and valgisation of the femoral neck and medial displacement of the shaft by intertrochanteric osteotomy were carried out (Figures 18-B). Moreover, the abductor muscles were released. The limb was immobilized in a long hip spica cast for two months. The patient was relieved from pain six months after operation. Stability of the hip was also gradually regained in the course of one year thereafter. Roentgenograms made five years after operation showed marked restoration of the degenerative changes (Figure 19). As may be seen in this figure, the shelf created at the proper site was replaced with new bone and adapted itself to the femoral head, and the cartilage space increased in width. In the femoral head, the cyst was repaired and the longitudinal trabeculae placed in the vertical position markedly increased in number and thickness while decalcification occurred in the medial osteophyte. In this reconstructed joint, it is suggested that a load on the femoral head is transmitted vertically along the longitudinal trabeculae to the shaft and, in consequence, the medial osteophyte is released from mechanical stress. It is evident that the improvement of the mechanical condition in the joint, combined with reduction of pressure caused by muscle tension, resulted in reconstruction of the longitudinal trabeculae in the femoral head and decalcification of the medial osteophyte.

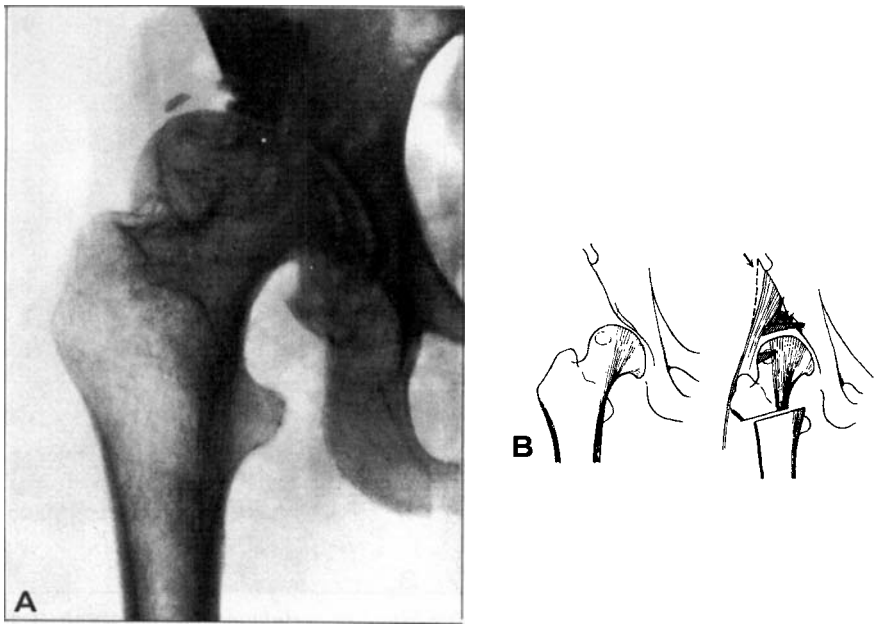

Figure 18. Case 6. A, osteoarthritic hip with an outward migration of the femoral head from the center of the acetabulum, accompanied by formation of a large medial osteophyte and a large cyst in the lateral portion of the femoral head, and almost complete obliteration of the articular space. B, diagram showing the combined procedures composed of the shelf operation, bone grafting in the cyst, valgisation of the femoral neck, medial displacement of the femoral shaft, and muscle release operation.

DISCUSSION

In this paper the biomechanism responsible for development of osteoarthritis in the dysplastic hip was considered on the basis of the results from clinical and experimental studies and also the study of the architecture of the trabeculae in the upper end of the femur. From the results obtained, the basic principles were defined for operative treatment for various types of osteoarthritis of the dysplastic hip.

It is supposed that in cases with acetabular dysplasia not only an excessive pressure on the small localized articular surfaces, but also a shearing stress acting on the longitudinal trabeculae of the femoral head plays an important role in the development of degenerative changes in the joint. Pathological changes which are thought to be caused by shearing stress on the longitudinal trabeculae are clearly seen in Cases 2 (Figure 13-A), 3 (Figure 14-A), 5 (Figure 17-A), and

Figure 19. Case 6, five years after operation.

6 (Figure 18-A). In cases 2, 5 and 6, the cyst is located in the lateral part of the femoral head which is subject to least pressure. In Case 3, several cysts are arranged in the oblique equatorial plane along which a shearing stress is thought to act.

In early cases with maked acetabular dysplasia, it was shown that the shelf operation, if it is performed with an exact technique and is combined with the muscle release procedure, arrests progress of degenerative changes in the joint and promotes its regeneration. In nine advanced cases, the joint was reconstructed by a combination of the shelf operation, valgisation with or without derotation of the femoral neck, medial displacement of the shaft and the muscle release procedure. In three other advanced cases, the joint was reconstructed by a combination of the shelf operation, varisation of the femoral neck, medial displacement of the shaft, and the muscle release procedure. In all these cases the pathological changes were repaired and numerous thickened vertical longitudinal trabeculae were reconstructed.

By means of the shelf operation, the contact areas of the articular surfaces increase in size, resulting in wide distribution of the load over the femoral head. By valgisation of the femoral neck, the longitudinal

trabeculae are released from shearing stress. By varisation of the femoral neck, the contact areas of the articular surfaces increase in size and the load on the femoral head is reduced due to relaxation of the muscles about the hip. However, the essential procedure for reconstruction of the dysplastic hip into the mechanically stable condition is the shelf operation combined with medial displacement of the shaft and release of the muscles about the hip by which the load on the femoral head is reduced, distributed widely over the femoral head, and transmitted vertically to the shaft. Under this condition, numerous thickened vertical longitudinal trabeculae are formed in the femoral head, even though the femoral neck is placed in the varus position, as shown in Case 3 (Figures 14-A and B).

The gains from cutting the bone, angulation and displacing the shaft are well documented, but the mechanism of pain and the reversal of the degenerative process is still obscure. The procedures advocated by *McMurray, Pauwels,* and *Voss,* are in fact variations of one procedure which must be modified according to the clinical and roentgenological findings. It is a mistake to use a stereotype technique for all patients. It is not realistic to expect one operation to be best for all of them. Though the greatest usefulness of the *Voss'* temporary hanging hip procedure is for a patient too old to withstand major surgery or with advanced arthritis of the hip and a range of hip motion too small to justify other procedures, this procedure is used also in combination with the shelf operation and valgisation of the femoral neck, as shown in the cases presented here. Though *Pauwels'* varus osteotomy gives an excellent result in patients with acetabular dysplasia accompanied by coxa valg luxans, the shelf operation combined with the muscle release procedure is also useful in patients with acetabular dysplasia too excessive to justify varus osteotomy.

The results obtained in our studies revealed that the shelf operation combined with the muscle release procedure is applicable to the early case with marked acetabular dysplasia and that the shelf operation combined with medial displacement of the shaft and muscle release procedure is applicable to advanced case. Furthermore, in these latter cases, varisation or valgisation of the femoral neck can be additionally done according to the clinical and roentgenological findings.

SUMMARY

1. The principles of treatment for osteoarthritis of the hip with incongruity were described. On the basis of the principles, the affected

hip was reconstructed into the mechanically stable condition by various combinations of the shelf operation, varisation or valgisation of the femoral neck, medial displacement of the shaft, and muscle release operation in 50 cases. In all cases good results were obtained.

2. In 38 early cases with a marked acetabular dysplasia, the shelf operation was performed in combination with release of the muscles about the hip.

3. In 12 advanced cases with a marked acetabular dysplasia and deformities of the femoral head and neck, the affected hip was reconstructed into the mechanically stable condition by combination of the shelf operation, intertrochanteric osteotomy, and release of the muscles about the hip, through which a load on the femoral head is reduced, distributed widely over the femoral head, and transmitted vertically to the shaft.

RESUME

1. Il est donné la description des principes du traitement de l'ostéoarthrite de la hanche. Sur la base de ces principes, la hanche a été reconstruite dans 50 cas de manière à obtenir une condition mécanique stable par différentes opérations combinées, butée complétant le toit du cotyle, varisation ou valgisation du col fémoral, déplacement médial du corps fémoral et relâchement des muscles. De bons résultats ont été obtenue dans tous les cas.

2. Dans 38 cas précoces avec dysplasie marquée du cotyle, l'opération de butée du toit a été pratiquée en combinaison avec le relâchement des muscles autour de la hanche.

3. Dans 12 cas avancés avec dysplasie marquée du cotyle et déformité de la tête et du col du fémur, la hanche atteinte a été reconstruite de manière à obtenir une condition mécanique stable par une opération combinée de butée du toit du cotyle, d'ostéotomie intertrochantérienne et de relâchement des muscles autour de la hanche, grâce à laquelle la charge sur la tête fémorale est réduite du fait qu'elle est plus largement répartie et transmise verticalement au corps du fémur.

ZUSAMMENFASSUNG

1. Die Prinzipien der Behandlung der osteoarthritischen, inkongruenten Hüfte werden beschrieben. Auf Grundlage dieser Prinzipien wurde die erkrankte Hüfte mittels veschiedener Kombinationen von Pfannendachoperationen, Varus und Valguseinstellung des Schenkelhalses, medialer Schaftverschiebung und Muskelauslösungoperationen in 50 Fäl-

len in eine mechanisch stabile Verfassung gebracht. In allen Fällen wurden gute Resultate erzielt.

2. In 38 frühzeitigen Fällen mit ausgesprochener Acetabulardysplasie wurde die Pfannendachplastik im Kombination mit der Auflösung der Muskeln der Hüftregion ausgeführt.

3. In 12 vorbeschrittenen Fällen mit ausgesprohener Acetabulardysplasie und Deformiteten des Femurkopfes und Halses wurde in der erkrankten Hüfte mittels Pfannendachplastik, intertrochanterer Osteotomie, Muskelauslösung der Hüftregion ein mechanisch stabiler Zustand wiederhergestellt, durch den die Belastung des Femurkopfes verringert, weit über den Femurkopf verteilt und vertikal auf den Schaft überführt wird.

REFERENCES

1. Adam, A. & Spence, A. J. (1958) Intertrochanteric osteotomy for osteoarthritis of the hip. *J. Bone Jt Surg.* **40** B, 219–226.
2. Blount, W. P. (1964) Osteotomy in the treatment of osteo-arthritis of the hip. *J. Bone Jt Surg.* **46** A, 1297–1325.
3. Hackenbrock, M. (1957) Die Arthrosis deformans des Hüftgelenkes. Beilage Zsch. Orthop. 88. In Verhandlungen der deutschen Orthopädischen Gesellschaft. 43. Kongress, 28–59.
4. Knodt, H. (1964) Osteo-arthritis of the hip joint. Etiology and treatment by osteotomy. *J. Bone Jt Surg.* **46** A, 1326–1336.
5. McMurray, T. P. (1935) Osteo-arthritis of the hip joint. *British J. Surg.* **22**, 716–727.
6. McMurray, T. P. (1939) Osteo-arthritis of the hip joint. *J. Bone Jt Surg.* **21**, 1–11.
7. Nakamasu, M.: Study on the trabeculae architecture of the upper end of the femur and its function. (In press).
8. Nicoll, E.A. & Holden, N. T. (1961) Displacement ostetomy in the treatment of osteoarthritis of the hip. *J. Bone Jt Surg.* **43** B, 56–60.
9. Nyakas, A. (1960) Zur operativen Behandlung der Arthrosis deformans des Hüftgelenkes. Zbl. Chir. **85**, 362–367.
10. Osborne, G. V. & Fahrnie, W. H. (1950) Oblique displacement osteotomy for osteoarthritis of the hip joint. *J. Bone Jt Surg.* **32** B, 148–160.
11. Ottolenghi, C. E. & Frigerio, Edgar (1962) Intertrochanteric osteotomies in osteoarthritis of the hip. Fundamentale, indications, techniques, and results. *J. Bone Jt Surg.* **44** A, 855–896.
12. Pauwels, Fr. (1950) Über eine kausale Behandlung der Coxa valga luxans. *Zsch. Orthop.* **79**, 305–315.
13. Pauwels, Fr. (1961) Neue Richtlinien für die operative Behandlung der Koxarthrose. Beilage *Zsch. Orthop.* **94**. In Verhandlungen der Deutschen Orthopädischen Gesellschaft, 48. Kongress, 332–366.
14. Voss, C. (1956) Koxarthrose – Die temporäre Hängehüfte. *Münchener Med. Wochenschr.* **98**, 954–956.
15. Yokosaki, M. (1964) Experimental study on osteoarthritis of the hip joint secondary to acetabular dysplasia. *J. Jap. Orthop. Ass.* **38**, 1–26.