Bosworth hip shelf arthroplasty in adult dysplastic hips: ten to twenty three year results

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Abstract

Purpose Hip shelf arthroplasty is currently considered to be a salvage procedure. The aim of the study is to present outcomes of Bosworth hip shelf arthroplasty in adolescent dysplastic hips with a minimum ten-year follow-up.

Methods The basic group comprised 25 hips in 18 patients with the mean age of 31 years (range, 16–52) at the time of operation. Subgroup A included 20 hips that were evaluated prior to operation as spherical, centric hips without osteoarthritic changes (acetabular dysplasia). The heterogeneous subgroup B comprised five hips. Of these, three hips were evaluated as aspheric, without osteoarthritic changes, and two hips as aspheric, with osteoarthritic changes of grade 2 according to Tönnis. In addition, two hips in subgroup B were evaluated as decentred (subluxated), one hip without and one hip with osteoarthritic changes. The mean follow-up was 15 years (range, ten–23).

Results In subgroup A, the positive effect of operation had lasted at the time of the final follow-up for ten to 22 years postoperatively (average follow-up 14 years) in 19 hips. Only one female patient, 46 years old at the time of operation, developed hip osteoarthritis within ten years, that was treated by THA. In subgroup B, a lasting positive effect of

operation was recorded in two cases at the time of the final follow-up (12 and 15 years). The third female patient with an aspheric and decentred hip developed severe hip osteoarthritis 21 years after shelf procedure that was treated by THA. In two patients who had hip osteoarthritis already before the operation, the positive effect of the shelf procedure survived over 13 and 20 years. Although hip osteoarthritis progressed, THA was performed as late as 15 and 23 years after the shelf procedure. The mean Harris hip score in 21 hips with a still functional hip shelf was 68 (range, 56–82) before and 90 (range, 76–100) after the surgery.

Conclusion The best outcomes of Bosworth hip shelf arthroplasty may be expected in a dysplastic spherical centred hip without osteoarthritic changes. In the presence of asphericity, decentration and osteoarthritic changes, neither the effect of the surgery nor its survival can be clearly predicted.

Introduction

Shelf arthroplasty for dysplastic hip was described for the first time by Franz König [1] in 1891. Subsequently, other authors published their own modifications. Bosworth published his technique of hip shelf arthroplasty and its outcomes in children in 1960 [2] and in adults in 1961 [3]. At that time hip shelf arthroplasty was the most frequently used coverage procedure [4]. In the 1970s, new coverage procedures were described, i.e. pelvic and acetabular osteotomies, which are currently preferred [5–9]. Despite a number of positive references [10–15], shelf arthroplasty is considered to be merely a salvage procedure [9]. However, our long-term experience in the Bosworth technique of hip shelf arthroplasty is positive. In this study, we present outcomes in adults with a minimum ten-year follow-up.

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Patients and method

Patient groups

The basic group included patients treated for dysplastic hips by Bosworth hip shelf arthroplasty, with minimal follow-up of ten years. The whole group was operated on by the first author between 1987 and 1998. It comprised in total 18 skeletally mature patients, one male and 17 females, with a mean age of 31 years (range, 16–52) at the time of surgery. At the time of operation, the age of five patients was in the second decade, eight patients in the third decade, four in the fourth decade, six in the fifth decade and one patient in the sixth decade, i.e. more than half of the patients in the group (11 patients, 14 hips) were older than 30 years. In total, 25 hips were operated on, seven patients bilaterally with the interval between operations of one year in five cases, two years in one case and ten years in one case. Twenty-three hips were not previously operated on. One patient underwent open reduction of the dislocated hip and intertrochanteric osteotomy in childhood and at the time of indication of shelf arthroplasty she already had osteoarthritic changes of grade 2 of the Tönnis classification [16]. In the second patient, the first shelf procedure, which was made when she was 13, had failed.

The basic group of patients was divided into two subgroups. Subgroup A included 20 hips that were evaluated prior to operation as spherical, centric and without osteoarthritic changes (acetabular dysplasia). The heterogeneous subgroup B comprised five hips. Of these, three hips were evaluated as aspheric, without osteoarthritic changes, and two hips as aspheric, with osteoarthritic changes of grade 2 according to Tönnis. In addition, two hips in subgroup B were evaluated as decentred (subluxated), one hip without and one hip with osteoarthritic changes. Changes in terms of femoroacetabular impingement were not evaluated [17]. The mean follow-up in all hips was 15 years (range, ten–23).

Method

In all the patients a pelvic radiograph and AP radiograph of the affected hip were taken. Indications for operation were patients with pain in the hip persisting for at least one year, not responding to conservative treatment, and with a radiographic finding of insufficient coverage of the femoral head, i.e. decreased values of the Wiberg CE [18] and Sharp angles [19]. Significant limitation of range of movement prior to operation was recorded only in one patient after a previous open reduction and intertrochanteric osteotomy.

Operative technique

Patients were operated on in the supine position, using the Smith-Petersen approach in the interval between the sartorius

and the tensor fasciae latae muscles. In the next step, the anterior part of the gluteus minimus and the gluteus medius muscles were stripped off the external aspect of iliac wing. Stripping started close proximally to the joint capsule and continued in the proximal and posterior direction as far as the anterior gluteal tuberosity. Such dissection preserves better integrity of muscles, and facilitates their release from the iliac wing together with the periosteum and exposure of the anterosuperior surface of the joint capsule and the adjacent acetabular rim. Subsequently, the origin of the reflected head of rectus femoris was identified and detached from the bone. Thus, the anterosuperior aspect of the joint capsule, including its attachment to the superior acetabular rim, was exposed. The superior acetabular rim with superficial fibres of the joint capsule was osteotomized and partially removed. An arch-shaped slot, approximately 25-mm broad and 8-mm high, was made in the prepared vertical surface, copying the superior acetabular rim and running obliquely proximomedially as far as the internal cortex of iliac wing. Arthrotomy was not performed. Then a trapezoidal graft formed by outer cortex and the adjacent cancellous bone was harvested from the iliac wing anteriorly to the anterior gluteal tuberosity. Where possible, the internal cortex of the iliac wing was preserved. The size of the trapezoidal graft was approximately $3 \times 6 \times 6 \times 2$ cm and its thickness about 6 mm. After adjustment, the graft from the outer concave cortex placed against the superior surface of the joint capsule was firmly hammered into the slot in such a way as to cover the anterolateral aspect of the femoral head and to rest on the capsule. Motion of the hip was checked to find out whether the graft did not restrict its full range, and where necessary the graft was made smaller. The next step included meticulous reinsertion of gluteal muscles and closure of wound. The reflected head of rectus femoris was not reinserted. The mean duration of operation was 55 min (range, 35–75 min).

Aftertreatment

The AP radiograph of the hip was performed immediately after surgery. Patients started walking from the second postoperative day without weight-bearing and with hip flexion exercises up to 80°. Progressive weight-bearing started after the first clinical and radiological control six weeks after surgery. After three months the patients were already fully weight-bearing. The next clinical and radiographic controls were scheduled at six months and one year postoperatively.

Evaluation

All but four patients were evaluated in terms of subjective satisfaction with the operation as well as with the Harris hip score (HHS) [20] prior to operation and at the final follow-up. The exceptions were four female patients who underwent THA after the shelf operation. In these patients HHS was not

evaluated at the final follow-up. CCD, Wiberg and Sharp angles were measured on the radiographs in all the patients pre- and postoperatively. Evaluation included also the onset or progression of osteoarthritic changes, using the Tönnis classification. Intra- and postoperative complications were recorded.

Results

Clinical and radiological evaluation

In all 25 hips the graft was osteointegrated within three months postoperatively without migration, although its complete remodelling lasted for several years after the operation (Fig. 1).

In subgroup A which included 20 hips, the positive effect of operation had lasted to the time of the final follow-up for ten–22 years postoperatively (average follow-up 14 years) in 19 hips. Only one female patient, who was 46 years old at

the time of operation, developed hip osteoarthritis within ten years, which was treated by THA.

In subgroup B which included five hips, a lasting positive effect of operation was recorded in two cases at the time of the final follow-up (12 and 15 years). The third female patient with an aspheric and decentred hip developed severe hip osteoarthritis 21 years after the shelf procedure that was treated by THA. In two patients who had hip osteoarthritis already before the operation, the positive effect of the shelf procedure survived over 13 and 20 years. Although hip osteoarthritis progressed, THA was performed as late as 15 and 23 years after the shelf procedure.

In summary, THA was performed in four female patients aged 30, 33, 41 and 46 years at the time of operation. The interval between shelf arthroplasty and THA was ten, 15, 21 and 23 years.

Fig. 1 Excellent radiological and clinical results. **a** Female, 37 years old, acetabular dysplasia, centred hip, severe subjective complaints. **b** Radiograph immediately after surgery. **c** Osteointegration of the graft one year after operation. **d** Excellent subjective, radiological and functional result 14 years after operation

Fig. 2 Shelf operation after a previous failed surgery. **a** Pre-operative radiograph of a 30-year-old female with decentred aspheric hip after previous failed shelf operation. **b** Postoperative radiograph; this case required fixation of the graft with a screw. **c** Osteointegration of the graft three months after operation. **d** Fifteen years after operation there was very good coverage and complete graft osteointegration

The mean HHS of 21 hips with the functional hip shelf was 68 (range, 56–82) before operation, and 90 (range, 76–100) after operation.

Coxometry

The mean CCD angle was 142° (range, 126 – 150°), of this in ten patients it was 140° or more. CE angle was 16° (range, -15° to 20°) before the operation and 32° (range, 25 – 45°) after osteointegration of the graft; the Sharp angle changed from 46° (range, 38 – 55°) before operation to 36° (range, 26 – 40°) after operation.

Complications

In all the patients surgical wound healed without complications, and no early or late infection was recorded. Similarly, no intra-operative complication was encountered. Only in

two cases was the graft too big and in one case it slightly limited external rotation of the hip. In one patient with the previously failed shelf procedure, it was necessary to fix the graft with a cortical screw (Fig. 2). Five patients developed paresthesia postoperatively of the lateral femoral cutaneous nerve of the thigh that partially or completely disappeared over time. One patient sustained a non-displaced fracture of the graft after a fall within six months after the shelf operation (Fig. 3). The fracture fully healed without any impact on the functional outcome. In two patients we recorded partial resorption of the graft, but in spite of this the graft still sufficiently covered the femoral head. High position of the graft or postoperative graft migration was not recorded.

Discussion

Shelf procedure improves coverage of the femoral head, without changing orientation of the acetabulum. Klaue et al. [21] have proved, on the basis of CT examination of 14 hips, that the problem of shelf operation is an inadequate coverage of the femoral head in its posterolateral quadrant. However, in all their 14 cases the hip was subluxated. Indeed, position of the graft in relation to the femoral head depends on orientation of the supra-acetabular slot. Therefore the graft covers primarily the anterolateral quadrant of the femoral head.

Despite good results published in the past [22–25], shelf operation is currently used mainly as a salvage procedure [9, 21]. According to some authors, its main disadvantage is

Fig. 3 Graft fracture. **a** A 52-year-old female with acetabular dysplasia, centred hip. **b** Postoperative radiograph. **c** Follow-up six months after operation revealed broken graft after a fall. **d** Eleven years after operation, complete graft osteointegration and excellent functional result

Fig. 4 Bilateral shelf operation. **a** A 16-year-old girl with bilateral acetabular dysplasia, centred hips, immediately before shelf operation on the right side; shelf operation on the left side was performed one year later. **b** Radiological result 21 years after operation on the right hip and 20 years after operation on the left hip; excellent result both subjectively and objectively

considered the fact that the bone graft does not ensure an adequate articulation for the femoral head cartilage [14]. This statement is not quite precise. In a dysplastic acetabulum, the articular labrum is in most cases hypertrophic and the adjacent joint capsule is thicker. These structures are often overloaded by pressure of the outer part of the femoral head which is not covered by hyaline cartilage. Extra-articular bone graft provides mechanical support for the underlying joint capsule and, consequently, also for the articular labrum. Thus, direct articulation between the graft and the femoral head cartilage never occurs.

The shelf procedure is associated with a relatively low incidence of complications including, for example, high graft placement, inadequate size of graft, postoperative graft migration, postoperative graft fracture or postoperative graft

resorption. We also encountered some of these complications but the final outcome was influenced only in one case, described above, when a graft that was too large slightly limited external hip rotation. All the complications of shelf operation mentioned can be relatively easily treated and do not harm the hip.

Various modifications of hip shelf arthroplasty have been described in the literature. The Bosworth technique is relatively simple [2, 3]. Of greatest importance is the proper level and inclination of the supra-acetabular slot. The slot must be made close to the superior surface of the femoral head and situated deep enough obliquely in the proximomedial direction. Only then can the concave graft be properly inserted and get in the required contact with the femoral head. Some authors fix the graft with screws [20]. In our

Fig. 5 Shelf operation in advanced hip osteoarthritis. **a** A 30-year-old female patient after open reduction and intertrochanteric osteotomy at the age of two years with subluxation, marked narrowing of the joint space in the weight-bearing area, sclerosis and cysts in the femoral head. **b** Postoperative radiograph. **c** Graft osteointegration five months after operation. **d** Graft remodelling 12 years after operation; joint space still clearly visible; subsequent progression of osteoarthritis treated with THA 15 years after shelf operation

Fig. 6 Shelf operation in mild hip osteoarthritis. **a** A 41-year-old female patient with centred hip, acetabular dysplasia, and osteoarthritic changes. **b** Postoperatively, there was excessive size of the graft, however, it did not limit range of motion in the hip. **c** Graft osteointegration and remodelling ten years after operation. **d** Evident progression of osteoarthritis 20 years after operation, the effect of operation began to deteriorate and THA was performed three years later

view, it is not necessary under normal conditions. If the slot is deep enough, of the proper size and hammered deep enough, it is sufficiently fixed and allows functional after-treatment. We have never used fixation by plaster of Paris described by other authors [15, 26, 27].

The problem of most of the studies evaluating outcomes of shelf operation is a significant heterogeneity of the groups of patients being evaluated. Some studies evaluated outcomes in children, adolescents and adults together [10, 12, 23–27]. Another problem is the indication of the shelf operation. Evaluation of many groups is based primarily on the outcomes in subluxated or dislocated hips, less frequently in acetabular dysplasia [10, 12, 21, 23–27]. Some of these studies evaluated hips after septic arthritis, neuromuscular diseases, etc.

Despite the heterogeneity of groups of hips, most studies evaluated the effect of shelf operation positively. Highly valuable among these studies is a study published by Nishimatsu et al. [10] who followed up 119 hips treated by shelf operation for 24 years (range, 15–41) in a group of 108 patients with a mean age of 25 years (range, 1–56). In 25 hips intertrochanteric osteotomy was also performed. Pre-operative osteoarthritic changes, the age at operation and correct placement of the graft were important factors in determining the outcome. In this study there were statistical differences in outcomes between those patients aged less and those over 25 years of age.

Extraordinary is the case report by Rajakulendran et al. [28] who described an excellent outcome of shelf procedure after 75 years in a female patient operated on at the age of ten.

Good results of shelf operation were published by several authors [10, 18–20, 22]. Bosworth et al. [10] operated in total on 46, mostly subluxated or displaced hips in 33 adult patients, with a mean follow-up of nine years (range, three–25).

Migaud et al. [11] evaluated 56 hips in 48 patients with a mean age of 32 years (range, 17–56) and a mean follow-up of 17 years (range, 15–30). Pre-operative joint space narrowing was observed in 32 of 56 shelf arthroplasties. The severity of pre-operative osteoarthritis was the main factor that impaired the survivorship of shelf procedure. The authors concluded that shelf arthroplasty is best indicated for moderate dysplasia without severe osteoarthritis.

Fawzy et al. [12] published very good results in a group of 76 hips in 67 patients with a mean age of 33 years (range, 17–60 years) and a mean follow-up of 11 years (range, six–14 years).

Pompe and Anatolič [15] gained similar experience however, in a group comprising only 14 hips in 12 patients, with a mean age of 39 years (range, 17–42) with residual hip dysplasia. The mean follow-up was only four years (range, one to eight).

Haverkamp and Marti [13] combined hip shelf arthroplasty and valgus intertrochanteric osteotomy in 26 hips treated for secondary osteoarthritis. A spherical femoral head was found in ten hips in patients with a mean age of 37 years (range, 29–45) and a mean follow-up of 19 years after shelf operation. A

deformed femoral head was found in 16 hips in patients with a mean age of 30 years (range, 16–50) and a mean follow-up of 15 years. In both groups the authors achieved good results but in the group with a spherical femoral head the results were better. Conversion to THA was not necessary in any of the cases. We had a similar experience with shelf operation as a coverage procedure in combination with the valgus intertrochanteric osteotomy [29, 30].

The above overview shows that good long-term results of the shelf procedure may be expected in younger patients or patients with minimal or without osteoarthritic changes [10–12, 24–27]. This is confirmed by our experience. The best effect of surgery was recorded in spheric, centric hips without osteoarthritic changes. A positive effect of the shelf procedure is also documented by the fact that seven patients having had experience with operation on one side, underwent the operation on the other side (Fig. 4). In aspheric, decentred hips with osteoarthritic changes, the surgery postponed THA by 12–23 years (Figs. 5 and 6). For the sake of objectivity, it has to be noted that in three female patients with hip osteoarthritis of degree 1 to 2, not included in this study, and operated on at the age of 43, 47 and 48 years, THA had to be performed within two years after shelf operation. In all three cases, analysis showed a decentred aspheric hip.

Results of coxometry in our group have to be judged with reservation. Postoperative values of the CE and Sharp angles were influenced by the size of the graft, or its projection into the frontal plane. However, these values are not indicative of the size of the area of the femoral head covered by the graft.

Conclusion

Based on our results we consider hip shelf arthroplasty as a possible alternative to periacetabular osteotomy. The best results of shelf operation may be expected in a dysplastic spherical centred hip without osteoarthritic changes, even in patients in their fourth to sixth decades of life. In the presence of asphericity, decentration and osteoarthritic changes, neither the effect of the operation nor its survival can be clearly predicted.

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Conflict of interest The authors do not have any conflict of interest.

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