# The Cone hip stem

## A prospective study of 13 patients followed for 5 years with RSA

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**ABSTRACT We operated on 13 patients (14 hips) with dysplastic hips, mean age 42 (28–58) years, with a cementless Cone stem and followed them for 5 years, using the Merle d'Aubigné clinical score, conventional radiography and repeated radiostereometry analyses. The clinical scores improved markedly at 4 months and still more throughout the study. None of the patients complained of thigh pain. No stem showed radiographic subsidence, but 3 stems had radiolucent zones probably indicating fibrous ingrowth. Micromigration was measured at 4 months, 1, 2 and 5 years. The mean subsidence after 5 years was 0.27 mm and the mean posterior micromigration of the head was 0.74 mm. Most of the micromigration took place within the first 4 months. We conclude that the uncemented Cone stem used in dysplastic hips has shown a good clinical outcome so far and was found to be stable on conventional radiographs and using RSA technique.**

Total hip replacement in patients with congenital dysplasia of the hip (CDH) is a technical challenge because of anteversion of the femoral neck, since the femur has 10–14 degrees more anteversion than normal (Sugano et al. 1998). Even in mild dysplasia the femur has a smaller and more anteverted canal than normal, which is usually unsuitable for conventionally-shaped prosthetic stems. The Cone prosthesis (Protek, Berne, Switzerland) (Figure 1) represents another design and concept of a cementless femur implant. This stem secures primary rotational stability through the medial and distal parts, where the longitudinal ribs are impacted into the cortical bone (Schenk and Wehrli 1989). That differs from many conventional implants, where the rotational stability is provided by the proximal part and where the medial neck of the prosthesis is impacted against the calcar region.

Some conventional stems have shown poor results in CDH hips (Dickob and Martini 1996, Nagano et al. 1997, Kawamoto et al. 1998). In cases where the anteversion is marked, the Cone stem has a theoretical advantage, as it allows the surgeon to rotate the prosthesis as desired to ensure stability of the hip joint, while retaining rotational stability of the stem. A good primary stability is a prerequisite for the secondary stability in cementless implant designs. Moreover, since Kolstad et al. (1996) had obtained encouraging clinical results with a similarly constructed prosthesis—i.e., the Wagner revision stem—we were interested in examining the stability of the Cone stem in CDH cases. So far as we know, only one clinical follow-up study of the Cone stem has been reported. Kim et al. (1998) had good results in a 2–4.5 year follow-up study of 55 CDH hips. No RSA study on the Cone prosthesis has been described as yet.

We evaluated the clinical outcome, occurrence of radiolucency and migration of the Cone prosthesis in young patients with arthrosis due to hip dysplasia.

## Patients and methods

Between 1994 and 1995 we operated on 14 hips

Figure 1. The Cone hip stem.

(13 patients, 7 women) with hip osteoarthrosis caused by CDH. Their mean age was 42 (28–58) years. The dysplasia was classified radiographically, using Wiberg's method (1939). According to Wiberg, the center edge angle (CE) should be less than 20 degrees in a dysplastic hip and all hips in our study met this criterion. We also classified the hips by Crowe et al.'s method (1979) and found that 10 hips in our series had less than 50% dislocation, 3 hips between 50% and 75% dislocation and one hip more than 75% dislocation.

The Cone stem (Figure 1) is a grid-blasted titanium-aluminum-nobelium alloy with a conical shape. The conus angle is 5 degrees and it has eight longitudinal ribs with a height varying between 1 and 2 mm, which are supposed to provide good rotational stability. The CCD angle is 135°. At operation, the femur is reamed conically according to the contour of the implant. Primary stability is obtained when the longitudinal ribs are impacted into the cortical bone.

We used an anterolateral approach. For the acetabulum, we used 10 cemented Cenator cups (Corin LTD), 1 cemented Charnley cup (Thackery Ltd.) and 3 cementless Romanus cups (Biomet Incorp.). 13 stems were given a 28 mm head and 1 stem a 22 mm head, all made of cobalt chrome. No intra- or early postoperative complications occurred. No acetabulum was bone grafted.

As a routine in our clinic at this time, all patients with cementless implants were restricted to partial weight-bearing (15 kg) for 3 months.

The study was approved by the local ethics committee and all the patients gave their informed consent before inclusion.

### Clinical examination

The clinical examinations were done before operation, after 4 months, 1, 2 and 5 years, using the Merle d'Aubigné score (Merle d'Aubigné and Postel 1954). At the 5-year follow-up, the range of motion was not noted exactly in all patients, but compared only with the results at 2 years and none of the subjects showed a reduced range of motion.

### Radiography

An experienced musculoskeletal radiologist, blinded for the RSA and clinical results, examined the conventional radiographs that had been taken postoperatively and after 5 years. Any subsidence, radiolucency or hypertrophy of the femur was evaluated on anteroposterior and lateral views. We used the classification of Engh et al. (1987) to evaluate the fixation of the prosthesis and the degree of resorption was classified with Engh and Bobyn's method (1988).

### Radiostereometric analysis (RSA)

The RSA procedure has been described elsewhere (Selvik 1989, Kärrholm et al. 1997). At operation, 5-8 tantalum ball markers (1.0 mm) were inserted into the proximal femur in a carefully planned manner. Postoperatively, 2 RSA radiographs were exposed simultaneously with 2 x-ray tubes positioned at an angle of 40°. Two-dimensional measurements were made on a digitizing table (Biomedical Innovations AB, Umeå, Sweden). For calculation of migration, we used the computer program UMRSA (RSA Innovations AB, Umeå, Sweden). Micromigration of the center of the prosthesis head was related by the mathematically-calculated rigid body projected of the tantalum balls in the femur. The precision error of the RSA mea-

Table 1. Clinical outcome (Merle d'Aubigné)

| | Preop. | 4 months | 1 year | 2 years | 5 years |
|---|---|---|---|---|---|
| Pain | 1.9 | 5.5 [b] | 5.5 [a] | 5.6 [a] | 5.6 [a] |
| Walk | 2.6 | 3.8 [c] | 5.1 [b] | 5.0 [a] | 5.4 [b] |
| Motion | 4.9 | 5.2 [f] | 5.4 [e] | 5.8 [d] | |

P-values, [a] 0.001, [b] 0.002, [c] 0.005, [d] 0.02, [e] 0.05, [f] 0.7 (Wilcoxon signed rank)

surements was determined on 12 double examinations postoperatively and a 99% confidence interval was chosen (Mjöberg 1986). The errors were 0.25, 0.29, 0.66 and 0.75 mm for the x, y, z axes and the vectorial sum of these motions (maximal total point motion = MTPM), respectively. The initial RSA examinations were done within one week after surgery and the follow-ups at 4 months, 1, 2 and 5 years.

### *Statistics*

The values of migration are presented in absolute and in signed values. The Wilcoxon signed-rank test was used to evaluate the clinical score. P-values less than 0.05 were considered significant.

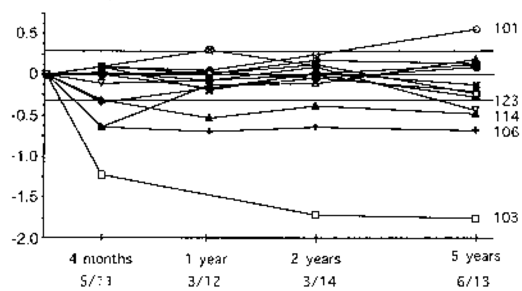


Figure 2. Subsidence over time (n = 14) in signed values. Below: Number of significant migrating prostheses /number available observations at each examination. Each line represents one patient.

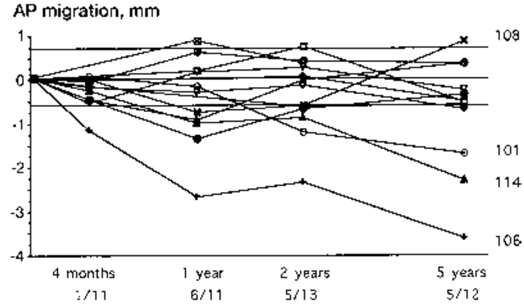


Figure 3. The anteroposterior migration over time (n = 14) in signed values. Below: Number of significant migrating prostheses/number of available observations at each examination. Each line represents one patient.

## Results

### *Clinical outcome*

The Merle d'Aubigné score improved at the follow-ups from 4 months from onwards (Table 1). The improvement continued throughout the study. 1 patient, who was not satisfied, gad a pain score of 4 at the 5-year follow-up and a loose cup on the conventional radiograph. Postoperatively, no patient complained of early thigh pain. No other symptoms or findings indicated a need for revision.

### *Radiography*

No stems showed any subsidence at the 5-year follow-up. 11 stems were fixated by bone ingrowth and 3 were stable but surrounded by a zone which could have been due to fibrous ingrowth (patient nos. 106, 113, 114) . Engh and Bobyn's classification (1988) showed that 11 stems had no signs of resorption, 2 stems had first degree (113,114) and 1 stem second degree resorption (106). 2 of these 3 stems (106, 113) had hypertrophy of the medial femoral cortex.

### *Radiostereometric analysis*

The mean subsidence after 5 years was 0.27 mm (median 0.23 mm), while the posterior migration of the head was 0.74 mm (median value 0.50 mm). 1 case (103) had subsided 1.23 mm at 4 months, but from 4 months to 5 years, the subsidence was 0.52 mm. This implant had a posterior migration of 0.58 mm, which is less than the value of precision (0.66 mm), and did well clinically. Most of the subsidence took place early in the postoperative phase (Figure 2). 4 patients (101, 105, 106, 114) showed a statistically significant posterior migration (i.e., more than the value of precision) of 1.69, 0,68, 3.63 and 2.30 mm (Figure 3). 2 of these stems had also subsided at the 4-month follow-up (106 114), 0.63 and 0.31 mm, but did not subside any further. The mean medial migration was 0.05 mm and the

Table 2. Migration (mm), (range), n = 14

| | 4 months | 12 months | 24 months | 60 months |
|---|---|---|---|---|
| Mediolateral | | | | |
| Absolut value | | | | |
| mean | 0.19 (0.01–0.77) | 0.26 (0.02–0.75) | 0.17 (0.001–0.61) | 0.22 (0.01–0.61) |
| median | 0.15 | 0.16 | 0.12 | 0.12 |
| Signed value | | | | |
| mean | 0.01 (0.26–0.77) | 0.05 (–0.32–0.75) | 0.02 (–0.28–0.61) | –0.05 (–0.48–0.61) |
| median | 0.07 | –0.02 | 0.01 | –0.07 |
| Proximodistal (subsidence) | | | | |
| Absolut value | | | | |
| mean | 0.30 (0.00–1.23) | 0.19 (0.02–0.69) | 0.27 (0.00–1.71) | 0.41 (0.09–1.75) |
| median | 0.10 | 0.09 | 0.11 | 0.26 |
| Signed value | | | | |
| mean | –0.25 (–1.23–0.10) | –0.12 (–0.69–0.30) | –0.15 (–1.71–0.24) | –0.27 (–1.75–0.56) |
| median | | –0.06 | –0.07 | 0.01 –0.23 |
| Anteroposterior | | | | |
| Absolut value | | | | |
| mean | 0.37 (0.02–1.81) | 0.82 (0.16–2.67) | 0.64 (0.02–2.34) | 1.01 (0.24–3.63) |
| median | 0.18 | 0.76 | 0.59 | 0.55 |
| Signed value | | | | |
| mean | –0.36 (–1.81–0.02) | –0.48 (–2.67–0.87) | –0.36 (–2.34–0.74) | –0.74 (–3.63–1.69) |
| median | | –0.18 | –0.29 | –0.15 –0.50 |
| MTPM | | | | |
| mean | 0.59 (0.10–2.07) | 0.90 (0.22–2.86) | 0.79 (0.08–2.50) | 1.21 (0.42–3.70) |
| median | 0.41 | 0.84 | 0.59 | 0.66 |

MTPM maximal total point motion

mean vectorial sum of these movements (MTPM) was 1.21 mm after 5 years (median 0.66 mm).

## Discussion

The clinical outcome of our patients was excellent and equal or even better than in other studies with uncemented stems (Garcia-Cimbrelo and Munuera 1993, Dickob and Martini 1996, Kim et al. 1998, Kawamoto et al. 1998). Several reports on cementless stems have shown a high incidence of thigh pain, when using titanium-based alloy instead of cobalt-chrome (Heekin et al. 1993, Bourne et al. 1994). However, this was not the case for the titanium alloy Cone implant. Wagner and Wagner (1995) suggested that good rotational stability is the reason why thigh pain is absent postoperatively. Kendrick et al. (1995) confirmed this explanation when he compared 4 stems of different designs on cross-sections, where the fluted design, which is similar to that of the Cone stem, was found to have the best rotational stability of the tested stems.

The radiographic findings in our study are similar to those reported by others (Engh et al. 1987, Hozack et al. 1993). 2 of the 3 stems with radiographic zones (nos. 106, 114) showed a significant posterior migration and early subsidence on the RSA examination. The subsidence (0.27 mm at 5 years), of the third stem (113) was not significant, while the posterior migration of this stem was impossible to evaluate for technical reasons. These first 2 stems may not have been primarily stable but nevertheless became secondarily stable because of the probable fibrous ingrowth. Engh et al. (1987) found a higher incidence of pain and limp in patients with fibrous ingrowth than in those with bone ingrowth, which did not accord with our findings in far fewer cases. The stem with the largest subsidence at RSA (patient no. 103, 1.75 mm subsidence) was classified as radiographically stable with probable bone ingrowth and showed no subsidence on the conventional radiographs. Malchau et al. (1995) claimed that the femoral head has to sink at least 5 mm before the subsidence would be detected with certainty by conventional radiographs and this could explain why the stem in patient 103 was regarded as radiographically stable.

Early subsidence, such as we found in 5 of 11 stems, has also been described in other studies of cementless stems (Kärrholm and Snorrason 1993, Önsten et al. 1995). Önsten et al. described the same posterior migration that we found, while Kärrholm and Snorrason (1993) reported an equal distribution between anterior and posterior migrations.

The forces acting on a stem have been described elsewhere (Carlsson et al. 1977, Wroblewski 1979). The most important load is applied from an anterosuperior direction. The small posterior migration that we found may indicate rotation, but it could also be the result of a combination of subsidence, posterior migration and varus tilt of the prosthesis. 2 of the 4 stems that migrated posteriorly also showed radiolucent zones. However, these radiographic findings were not related to the clinical findings, especially when no postoperative thigh pain was present. According to our observations, the Cone prosthesis is essentially malleable, probably because the longitudinal ribs provide implant rotational stability. If the primary stability is insufficient, the implant may stabilize after an initial period of subsidence, sometimes also with radiolucent zones as a sign of possible fibrous ingrowth.

Some authors have suggested, that early subsidence predicts later revision due to clinical loosening. Paterson et al. (1986) reported that of 72 sinking hips with cemented stems in a 7-year follow-up study, 70 developed a radiolucent zone within the first 2 postoperative years. Kärrholm et al. (1994) stated that the best predictor of revision within 5–7 years for cemented stems was the early micromigration measured with RSA. These authors also noted that the early migration of cementless stems should be less than 1–1.5 mm within the first 2 years to obviate early or midterm revision. Our study showed that a few stems subsided to a very small degree in the first months, but remained stable thereafter.

The present study has a few limitations. We examined only 14 hips in patients with dysplasia of the hip. It is uncertain to what extent the results can be extrapolated to primary arthrosis of the hip. A weakness in the RSA part of this study is that only one reference point of the implant could be clearly seen (i.e., the center of the head of the stem). Therefore, it was not possible to construct a three-dimensional geometric figure of the stem to study the exact pattern of rotation. For this reasons, the results of this RSA study must be interpreted with caution.

No competing interests declared.

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