

## THE RISK OF ACETABULAR PROTRUSION FOLLOWING PROSTHETIC REPLACEMENT OF THE FEMORAL HEAD

ODD SØREIDE, ROLF SKJÆRVEN & ANTTI ALHO

Departments of Surgery and EDP (Medical Faculty), University of Bergen, Haukeland Hospital, Bergen, Norway

A total of 214 patients treated with hemiarthroplasty showed a crude frequency of acetabular protrusion of 26 per cent. Two factors were associated with the development of protrusion: the length of the follow-up period and previous hip operation. The frequency of protrusion was estimated using logistic regression techniques based on information concerning the age of the patients, the length of the follow-up period and any previous hip operation. The frequency ranged from 4.8 per cent for a patient of 75 years or under, with a follow-up period of less than 12 months and no previous hip operation, to 61 per cent for patients of over 75 years, with a follow-up period exceeding 12 months, and a previous hip operation. Patients of over 75 years were 1.7 times more likely to develop protrusion than younger patients, patients previously operated on were 2.3 times more likely to develop protrusion than those not operated on previously, and patients with a follow-up time period exceeding 12 months were 7.9 times more likely to develop protrusion than patients with a shorter follow-up time.

*Key words:* acetabular protrusion; hip prosthesis

Accepted 14.iv.82

Prosthetic replacement (hemiarthroplasty) of the femoral head is widely recommended for acute femoral neck fractures and for complications following internal fixation of these fractures. We have shown previously that acetabular protrusion occurs in a significant number of patients following this operation, and that protrusion is closely associated with the development of postoperative pain (Søreide et al. 1981). Similarly we have shown that the development of protrusion is closely associated with a longer follow-up period and whether or not the patient has been operated on previously (previous hip operation).

Given information about the follow-up period, any previous hip operation and the age of the patient (which is of interest from a theoretical point of view), is it possible to predict the development of acetabular protrusion? In what way

will changes in the level of the explanatory variables (for instance increasing the follow-up period) affect the development of acetabular protrusion?

### PATIENTS

A total of 214 patients (mean age 82.5 years, SD 7.5 years, range 57-99 years) treated with Christiansen's trunnion bearing hemiprosthesis, either for acute femoral neck fractures (176 patients) or for failure following previous hip operation (internal fixation, 38 patients) were studied. The method of recording acetabular protrusion has been published previously (Søreide et al. 1981), and the preoperative, peroperative and postoperative factors which could be associated with the development of protrusion were studied in detail. The mean follow-up period was 21.9 months (SD 22.5 months, range 1-84 months).

## Methods and statistical analyses

The variables of interest have been dichotomized, as shown in Table 1. The general relationship among the variables under study has been studied by fitting log-linear models to the data (Fienberg 1977). The logistic model (Cox 1970; for details see Appendix) was adopted in order to predict the proportion of patients developing protrusion at particular levels of the explanatory factors. It was also used to study how the effect of being at one level of protrusion (dependent variable) varies with an exact combination of levels of the other (independent) variables. Based on the parameters in the logistic model, the odds ratio for each variable was calculated. An odds ratio gives information about the relative changes which occur in any cell when the explanatory variables are changed from one level to another (for instance, if the odds ratio for previous hip operation/no previous hip operation is 2.3, this means that a patient previously operated on is 2.3 times more likely to develop protrusion than a patient not previously operated on). The statistical analyses were performed with the BMDP (Dixon & Brown 1979) and GLIM (Baker & Nelder 1978) program packages implemented on the UNIVAC 1000 installation at the University of Bergen.

Table 1. Variables under study

Variable	Categories
1. Protrusion (P)	No (1) Yes (2)
2. Previous hip operation (T)	No (1) Yes (2)
3. Follow-up time (in months) (S)	0-12 (1) >12 (2)
4. Age of patient (A)	≤75 (1) >75 (2)

## RESULTS

The number of patients with acetabular protrusion and the total number of patients for every combination of the categories of the explanatory variables (see Table 1) are given in Table 2.

*General relationship among the variables.* A log-linear analysis of the four-way table (Table 2) incorporating interaction effects between protrusion and follow-up period, between protrusion and previous hip operation, and only main effect for the variable, age of the patient (no interaction with protrusion) gave good fit to the data ( $\chi^2_{LR} = 9.4$ , d.f. 9,  $P = 0.402$ ). This model explains 96.6 per cent of the total variation in the data (see Appendix).

*Prediction of the development of acetabular protrusion.* Multiple logistic regression analysis was used to determine the independent prognostic value for each of the variables (age, follow-up period and previous hip operation) for the development of acetabular protrusion. The results of the analyses are shown in Table 3 and Figure 1. The frequency of acetabular protrusion ranges from 4.8 per cent for a patient aged 75 years or under with a follow-up period of less than 12 months, who has not been operated on previously, to 61 per cent for a patient of over 75 years of age, with a follow-up period exceeding 12 months, who has been operated on previously.

Table 2. Frequency of acetabular protrusion and total number of patients for every combination of the explanatory variables

Age of patients	Follow-up time	Previous hip operation	Protrusion (No. of patients)	Total no. of patients
≤75 years (1)	≤12 months	No (1)	0	11
		Yes (2)	1	4
	>12 months	No (1)	5	18
		Yes (2)	4	8
>75 years (2)	≤12 months	No (1)	6	76
		Yes (2)	2	12
	>12 months	No (1)	29	69
		Yes (2)	9	16

Table 3. Multiple logistic regression of risk of development of acetabular protrusion following femoral head replacement

Regressor	Effect	t	Odds ratio
Age > 75 years ( $u_1^A$ )	0.53 ± 0.44	1.20	1.7
Follow-up time > 12 months ( $u_2^S$ )	2.07 ± 0.41	5.05	7.9
Previous hip operation ( $u_3^T$ )	0.82 ± 0.41	2.00	2.3
Grand mean ( $\bar{u}$ )	-2.97 ± 0.55	5.40	-

The relative changes in the development of protrusion on changing the categories of the explanatory variables. The odds ratio for each explanatory variable is given in Table 3. The odds ratio for age was 1.7, which means that a patient of over 75 years is 1.7 times more likely to develop protrusion than a patient of 75 years or under. The effect of age was not, however, significant. The odds ratio for previous hip operation was 2.3, which means that a patient with a previous hip operation was 2.3 times more likely to develop protrusion than a patient without a previous operation. Similarly, the odds ratio for follow up period was 7.9 which means that a patient with a follow-up period exceeding 12 months is 7.9 times more likely to develop protrusion than a patient with a follow-up of 12 months or less.

DISCUSSION

The present analysis demonstrates how the development of acetabular protrusion is affected by changing the levels of the explanatory factors – follow-up period, previous hip operation and age – in decreasing order of importance. The figures

given in Figure 1 may be of value for a prospective evaluation of a patient.

The length of the follow-up period was, not surprisingly, the most significant factor when predicting protrusion, and we have been able to give figures to quantify how much more likely patients are to develop protrusion when the follow-up period is increased from 12 months or less to over 12 months. (The odds ratio given is, of course, an average figure for the whole period between 1 and 12 months, and between 13 and 84 months). The increased risk of acetabular protrusion on increasing the follow-up period is put even more clearly into focus when the life expectancy of these patients is taken into consideration. The life expectancy of a female patient aged 60, 65 or 70 years treated for an acute femoral neck fracture has been previously estimated to be 18.7, 13.9 and 9.8 years, respectively (Søreide & Lillestøl 1980). The association between acetabular protrusion and pain has been clearly demonstrated (Søreide et al. 1981). Thus it is clear that femoral head replacement with a hemiendoprosthesis in these age groups should be avoided. Patients with a previous hip operation were found to be 2.3 times more likely to develop protrusion than patients not operated on previously.

APPENDIX

In this study we have fitted a logistic model to the data in the four-way table (Table 2).

Using the notations given in Table 1, we can formulate the logistic model:

$$Z_{ijk} = u + u_i^T + u_j^S + u_k^A + u_{ij}^{TS} + u_{ik}^{TA} + u_{jk}^{SA} + u_{ijk}^{TSA}$$

where  $i, j, k = 1, 2$

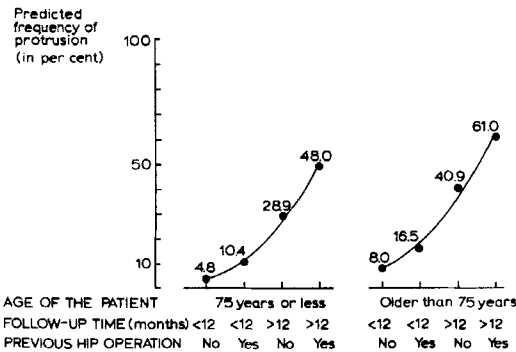


Figure 1. Estimated frequency of acetabular protrusion.

$Z_{ijk}$  is the logistic transformation of the probability,  $P_{ijk}$  of the occurrence of acetabular protrusion, given information about the variables: previous hip operation (T), follow-up period (S) and age of patient (A), and is defined as

$$Z_{ijk} = \log e \left[ \frac{P_{ijk}}{(1 - P_{ijk})} \right]$$

$i$ ,  $j$  and  $k$  indicate the levels of the three variables T, S and A as noted in Tables 1 and 2.

$Z_{ijk}$  is sometimes called the logit.

The parameter  $u$  can be interpreted as the overall mean,  $u_i^T$ ;  $u_j^S$  and  $u_k^A$  denote the main effects of the variables T, S and A respectively,  $u_{ij}^{TS}$ ,  $u_{ik}^{TA}$  and  $u_{jk}^{SA}$  are two-way interaction effects and  $u_{ijk}^{TSA}$  is the three-way interaction effect. It would thus seem that we must estimate 27 parameters, but, as in ANOVA models, constraints reduce the number of independent parameters to 8.

The model formulated here is a saturated model. Our aim is to reduce the number of parameters in order to obtain a simple model which makes good sense. In a forward-stepping manner we incorporate one parameter at a time. By using the difference in log likelihood ratio  $\chi^2$  for the different models we find that the model incorporating only main effects reduces the  $\chi^2$  from 40.54 (7 degrees of freedom) to 2.00 (4 degrees of freedom). This model fits the data well

( $P = 0.74$ ) and explains 95 per cent of the total variation in the table.

We used the program package GLIM to obtain our results. GLIM is so designed that the first level of the different factors is incorporated into the mean parameter  $u$ , i.e.  $u$  gives us the logit value of the cell with values  $i = 1, j = 1, k = 1$ , i.e. no previous hip operation, follow-up period  $\leq 12$  months and age below 75 years. ( $u_1^T = u_1^S = u_1^A = 0$ ).

The results given in Table 3 are thus sufficient to describe the results of the study.

## REFERENCES

- Cox, D. R. (1970) *The analysis of binary data*. Methuen, London.
- Baker, R. J. & Nelder, J. A. (1978) *The Glim-system, Generalized Linear Interactive Modelling*. NAG, Oxford.
- Dixon, W. J. & Brown, M. B. (1979) *BMDP-79, Biomedical computer programs*. University of California Press, California.
- Fienberg, S. E. (1977) *The analysis of cross-classified categorical data*. MIT Press, Mass.
- Søreide, O. & Lillestøl, J. (1980) Survival patterns following primary prosthetic replacement for acute femoral neck fractures in the elderly. *Scand. J. Soc. Med.* **8**, 73–80.
- Søreide, O., Lillestøl, J., Alho, A. & Hvidsten, K. (1981) Acetabular protrusion following endoprosthetic hip surgery: a multifactorial study. *Acta Orthop. Scand.* **51**, 943–948.

Correspondence to: Odd Søreide, M.D. Department of Surgery, University of Bergen, N-5016 Haukeland Sykehus, Norway.