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A modular femoral implant for uncemented stem revision in THR

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Abstract We present the early results of 142 uncemented femoral stem revisions using the modular MRP-Titan system. There were 70 cases with marked preoperative femoral bone defects (Paprosky type 2C and type 3); and bone grafts were used in 31 cases. At a mean follow-up of 2.3 years five cases were re-revised due to dislocation and two due to aseptic loosening. The mean Harris hip score improved from 37.4 preoperatively to 92.4. In 122 cases progressive bone regeneration on X-ray was seen; and no further osteolysis was observed.

Résumé Nous avons évalué les premiers résultats de 142 opérations de changement de la prothèse fémorale sans ciment avec le système MRP-Titan modulaire. Dans 70 cas on a observé avant l'intervention des altérations importantes du fémur (typ 2C et typ 3 après Paprosky). Une greffe osseuse dans la zone de défaut n`a été nécessaire que dans 31 cas. Pendant un temps postopératoire de 2.3 années en moyenne, deux implant a dû être changé à cause d`un descellement aseptique de la prothèse. Une deuxième opération a été nécessaire dans cinq cas à cause de luxations répétées. Au niveau fonctionnel, on mesure une amélioration du score de Harris de 37.4 points à 92.4 points. Dans 122 cas on a trouvé un rétablissement de la structure osseuse avec une régénération dans la zone de défaut. Des ostéolyses locales n`ont pas été visibles.

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Introduction

In the majority of cases of aseptic loosening after total hip replacement (THR), significant metaphyseal femoral bone defects are noted. The use of further cement under these circumstances may not give good long-term results [29], and the use of uncemented femoral revision stems has been advised [6, 10, 13, 20, 28]; however, only the results following implantation of non-modular uncemented prostheses or custom-built prostheses have been presented. The major disadvantage of these systems is that intraoperative adjustments of neck length and anteversion angle are not possible. The modular revision prosthesis system (MRP-Titan; Peter Brehm, Weisendorf, Germany) was developed in an attempt to address these problems.

Materials and methods

The design of the MRP-Titan stem includes: distal fixation (length 140 mm straight, 200 mm straight, 200 mm curved) with radially arranged conical longitudinal fins; an extension sleeve whose length is 30 mm and is available in several diameters; a variety of neck lengths (50 mm, 60 mm, 70 mm) and the standard tapered cone (12/14) with a locking screw to ensure force transmission via the cone, and a screw to assemble the construct and prevent tissue ingrowth (Figs. 1, 2). The prosthesis is made of titanium alloy Ti6Al7Nb, the surface of which is roughened to a pore size of Rz 40–60 µm to allow bony ingrowth. The cone connections with adjustable rotation in a range of lengths allow the surgeon to choose a length of prosthesis between 190 mm and 300 mm intraoperatively. In cases with osteolytic defects affecting the isthmus where primary stable fixation is difficult to achieve, this system provides distal holes for locking screws.

The relevant details of 142 MRP-Titan stems introduced into 141 patients in this prospective study are presented in Table 1.

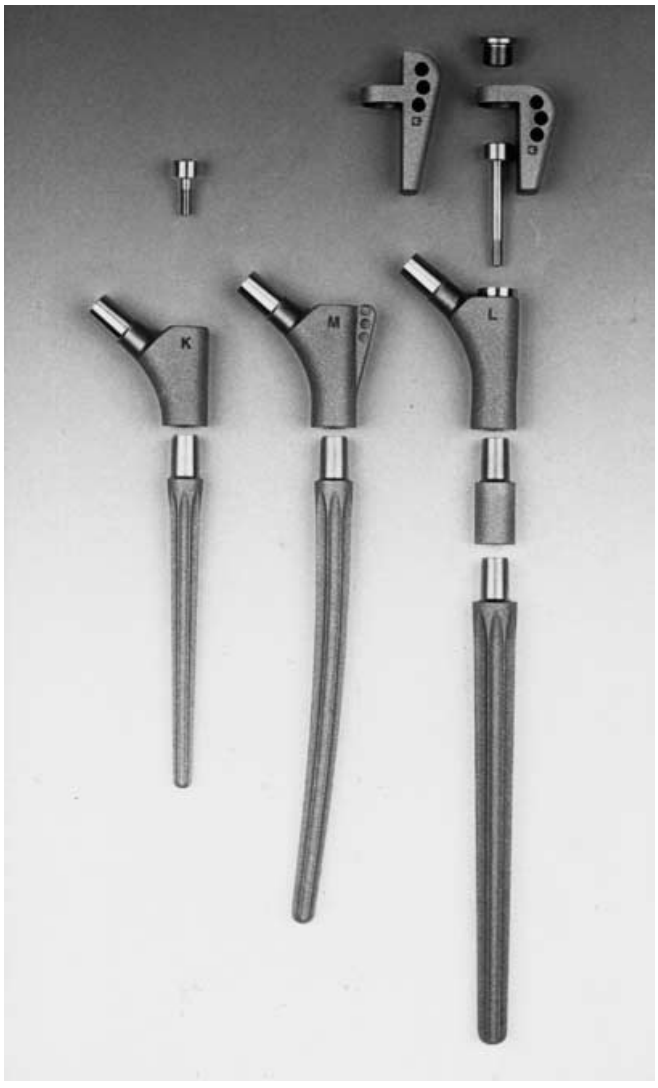

Fig. 1 Modular components of the MRP-Titan system

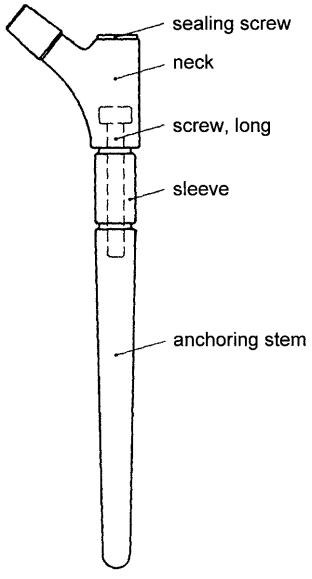

Fig. 2 Schematic presentation of the modular design

The mean follow-up was 2.3 years (1–6.3 years). In all cases the acetabular component was also revised. The Charnley and Harris function scores [5, 11] pre- and post-operatively are shown in Table 2. AP X-rays of the pelvis and of the affected hip and a Lauenstein projection view were routinely performed and pre-operative assessment of radiolucent lines was made according to the criteria of Kavanagh and Fitzgerald [17], and of proximal femoral bony defects using the Paprosky classification [25] (Table 1). The post-operative and follow-up X-rays were evaluated for radiolucent lines, axial migration of the stem, varus or valgus alignment of the prosthesis and rotation of the implant. Implants with an axial migration of 5 mm or associated with progressive osteolysis were considered to be unstable or loose. Tilting of the prosthesis was determined by comparing the angle between the longitudinal axis of the shaft of the femur and that of the implant. Changes in this angle of more than 5° were considered significant. Rotation of the implant was assessed on the basis of comparison between specific landmarks of the implant and the femur, e.g. lesser trochanter, greater trochanter, the shoulder of the implant and the position of the neck of the prosthesis. Periprosthetic bone remodelling, bone resorption, progressive radiolucent lines and evidence of osteolysis were assessed as described by Engh [7, 8]. Periarticular ectopic ossification was classified as described by Brooker [1].

Results

A significant improvement in the mean Harris hip scores was noted within the first post-operative year ($P<0.001$); and at a mean follow-up of 2.3 years this improvement was maintained and there were no differences in the scores of the different Charnley groups (A, B or C; Table 2). No differences were seen in the functional results when comparing patients with minor femoral bony defects (type 1, type 2A and type 2B) compared with those with extensive defects (type 2C and type 3; Fig. 3).

The early and late complications are summarised in Table 3. There was satisfactory distal fixation in all cases. There were two cases of late infection (1.4%) managed by soft-tissue debridement without the necessity of removing the stem. There were 11 isolated cases of dislocation successfully treated by manipulation and conservative management. There were five cases of recurrent dislocation (3.5%) managed by alteration of the

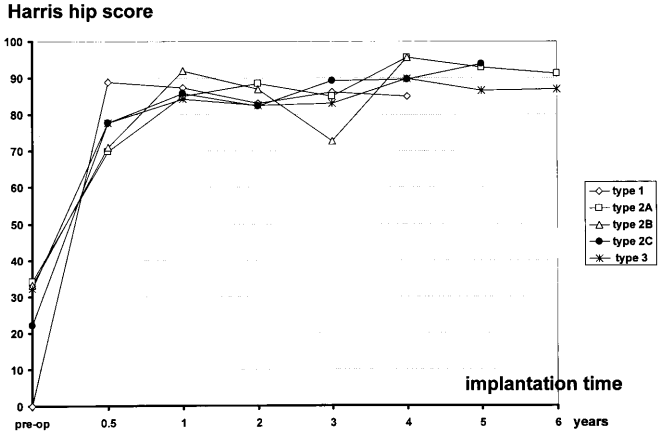

Fig. 3 Harris hip score in the pre/post-operative course as a function of the pre-operative bony defect (Paprosky classification)

Table 1 Patients' data, indications for replacement and preoperative femoral bone defects (*THA* total hip arthroplasty, *yrs* years)

Patients' data	*n*
MRP-Titan stems	142
Patients	141
Men	51
Women	90
Left	74
Right	68
Age of patients	Mean: 67.4 yrs; range: 32.1–89.9 yrs
Weight of patients	Mean: 74.5 kg; range: 48–90 kg
Height of patients	Mean: 165.5 cm; range: 142–190 cm
Indications for replacement	
Aseptic loosening of cemented stems (primary THA)	85
Aseptic loosening of uncemented stems (primary THA)	42
Septic loosening of cemented stems (primary THA)	4
Girdlestone situation	4
Second revision for aseptic loosening	6
Third revision for aseptic loosening	1
Bone defect type (Paprosky classification)	
Type 1	17
Type 2A	35
Type 2B	20
Type 2C	31
Type 3	39

Table 2 Pre-/post-operative comparison of functional results achieved with the MRP-Titan implants (*n*=142)

Prefixes of Charnley	Harris hip score (0–100)			
	All	Type A	Type B	Type C
Preop (*n*=142)	37.4	41.8	32.4	38.1
0.5 yrs postop (*n*=142)	77.6	81.8	70	81.4
1 y postop (*n*=142)	92.4	91	94.2	92
2 yrs postop (*n*=55)	84.2	91	86.7	75
3 yrs postop (*n*=34)	84.3	88.4	84.6	79.1
4 yrs postop (*n*=29)	90.3	92	90.3	88.6
5 yrs postop (*n*=9)	89.5	90.6	87.9	90
6 yrs postop (*n*=4)	89.3	91.2	90.1	86.5

Table 3 Early and late post-operative complications

Early complications (<4 weeks)	
Phlebothrombosis	1
Pulmonary embolism	1
Haematoma requiring revision	2
Wound healing disorder requiring revision	1
Dislocation (total)	5
Isolated	3
Recurrent	2
Late complications(≥4 weeks)	
Dislocation (total)	11
Isolated	8
Recurrent	3
Deep infection requiring revision	2
Periprosthetic fracture	2
Ectopic ossification (≥ Brooker II)	2

modular neck anteversion; and thereafter there were no further dislocations.

X-ray evaluation at a mean of 2.3 years follow-up shows stable stem fixation with good prosthesis-bone contact. Remodelling of proximal femoral defects was seen in 122 cases (85.9%). In ten cases (7%) the proximal femoral deficiency was augmented by cancellous autograft, and in a further 21 cases (15%) by cancellous allografts. There were radiological changes (radiolucent lines) suggestive of soft-tissue interposition in six cases (4%). The position of the implant had not however changed in these patients and none was symptomatic. Instability of the stem with progressive osteolysis or migration (≥5 mm) was seen in six cases (4%) at an average of 17 months post-operatively. Two of these cases underwent a revision procedure; and the other four are awaiting further surgery. Thus 6 of the 142 implanted MRP-Titan stems (4%) have failed.

Periarticular ectopic ossification (Brooker type II-IV) was seen in two cases (1.4%) and removal of the ectopic bone with irradiation was performed in one case.

Discussion

The problems presented by proximal femoral deficiency in association with loosening of the femoral component must be addressed if stable fixation is to be obtained with a satisfactory functional outcome. Cement should not be

Table 4 Review of results of uncemented hip revision arthroplasties (*Fem. rev.* femoral revisions, *Follow-up* mean number of years, *Age* mean age of patients at revision arthroplasty, *Clin./rad. loosenings* clinical and radiological evidence of loosening with no re-revision, *Rerev.* re-revision procedures, *N.d.* no data provided)

Authors	Fem. rev. (*n*=1.784)	Follow-up (years)	Age (years)	Clin./rad. loosenings (%)	Rerev. (%)
Hedley et al. 1988 [15]	42	1.6	54.2	9.5	2.4
Engh et al. 1988 [6]	127	4.4	55.8	2.4	1.6
Gustilo and Pasternak 1988 [10]	57	2.8	59	1.8	4
Harris et al. 1988 [12]	60	>1 (1–3)	57	0	0
	23	>2 (2–6)		0	0
Mallory 1988 [20]	160	>2 (2–6)	N.d.	N.d.	5
Hungerford and Jones 1988 [16]	51	>2 (2–5)	54	7.8	4
Pasternak et al. 1988 [26]	109	2.5	57.3	8	9
Engh et al. 1990 [7, 8]	202	4.5	57.7	3.4	4
Morrey and Kavanagh 1992 [22]	91	3.2	N.d.	6	12
Pak et al. 1993 [24]	113	4.8	59.6	2.7	4.4
Cameron 1994 [3]	62	3.7	59	N.d.	16.1
	29	3.5	53	0	6.8
Head et al. 1994 [14]	177	3	N.d.	2	3
Lawrence et al. 1994 [18]	83	9	57	11	10
Moreland and Bernstein 1995 [21]	175	5	62.4	1.7	4
Hartwig et al. 1996 [13]	37	2.3	64	0	2.7
Mulliken et al. 1996 [23]	51	4.6	64	14	10
Malkani et al. 1996 [19]	69	2.8	62	20	8.7
Buoncristiani et al. 1997 [2]	66	4.7	56	0	6
Mean	Total 1.784	3.8	58.3	5.0	5.7
Present study	142	2.3	67.4	2.8	1.4

used under these circumstances [29]. Stable fixation of the revision implant is required within healthy diaphyseal bone distal to the fixation of the original prosthesis [6, 16, 28]. A revision stem must therefore bridge bone defects and allow the application of bone graft [28, 29]. The MRP-Titan stem was developed to incorporate sound distal fixation with a modular system to allow adjustment of length of the prosthesis and the angle of anteversion. Despite a relatively short follow-up the comparison of early results achieved with the MRP-Titan implant compared with other uncemented replacements shows a low loosening and re-revision rate (Table 4). Previous studies involving patients with extensive bone loss have included the use of "cortical strut or bulk allografts" [9, 14]. Cameron [3] reported a revision rate of 16.1% when using the S-ROM revision stem (Joint Medical, Stanford, Conn., USA) in patients with Paprosky type 3 defects, with a mean follow-up period of 3.7 years; and Chandler et al. [4] reported a 25% re-revision rate using the same implant in 52 cases with extensive bony defects and a mean follow-up of 3 years. In 11.5% of these cases, re-revision was required due to recurrent dislocation, while there was an aseptic loosening rate of 9.6%. In our cases with recurrent dislocation stability could be achieved by modifying the angle of anteversion without complete replacement of the prosthesis. A total of 136 of the implants (95.8%) showed satisfactory stable fixation with no clinical or radiological figus of loosening. Satisfactory distal fixation using other uncemented stems have been reported [13, 28]. Some authors have drawn attention to possible corrosion at the metal interfaces of modular systems [27] but we have seen no evidence of this in the early results of this study, and there have been no periprosthetic lucencies on X-ray as indication of wear-related connective tissue formation associated with the modular connections.

In summary, the modular MRP-Titan revision system used in revision hip surgery where there is extensive femoral deficiency has proved, in the short term, very successful. Stable primary fixation with bony remodelling has been shown. The modular aspects of the design allow for appropriate intraoperative adjustment of length of the prosthesis and angle of anteversion of the neck.

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