



# Age-related osseointegration of a short hip stem: a clinical and radiological 24 months follow-up

Sarah Boller<sup>1</sup> · Alexander Jahnke<sup>2</sup> · Laura Augustin<sup>1</sup> · Gafar Ahmed<sup>1</sup> · Markus Rickert<sup>1</sup> · Bernd Alexander Ishaque<sup>1</sup>

Received: 19 June 2018 / Published online: 1 December 2018  
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## Abstract

**Purpose** The purpose of this study was to examine potential differences between patients under and over 60 years who underwent a total short hip stem arthroplasty in a 24-month follow-up in a clinical setting.

**Methods** Sixty seven patients were included in this prospective study and divided in two groups. In the younger cohort 39 patients  $\leq 59$  years and in the older cohort 28 patients  $\geq 60$  years were included. Clinical and radiological examinations of the patients took place preoperatively, postoperatively and after 3, 6, 12 and 24 months. The Harris Hip Score (HHS) was raised as clinical examination. Changes of bone mass density (BMD), stress shielding, reactive lines, spot welds and sclerosing were examined as radiological analysis.

**Results** The HHS improved from  $53.6 \pm 8.2$  preoperative to  $93.2 \pm 9.6$  in the younger cohort and for the older cohort from  $57.6 \pm 14.8$  to  $94.1 \pm 7.6$  after 24 months. BMD growth was detectable in regions of interest (ROI) 3 and 6 for both groups. Different results between the cohorts could only be detected in ROIs 4 and 5. The older cohort showed a loss of BMD of 5.95% in ROI 4 and 3.17% in ROI 5 after 24 months, whereas the younger cohort showed no loss of BMD in both ROIs.

**Conclusions** No significant differences or any influences of osseointegration and clinical outcome of the short hip stem for both groups were detectable. Lower losses (ROIs 1 and 2) and higher growths (ROIs 3, 4, 5) were discovered in younger patients and the HHS improved in both groups. Reasons for this result could be age, sex or the level of activity of the patients, but in both groups the short hip stem shows comparable results in clinical as well as in radiological examination. We conclude that the short hip stem seems to be an adequate treatment also for older patients.

**Keywords** DXA · Short stem · Bone density · Densitometry · Age-related · Elderly

## Introduction

Short hip stems own 30% market share of the primary arthroplasty [1]. The number of total hip arthroplasty (THA) is still growing just as the quantity of older patients provided with a hip prosthesis [2]. Various studies have shown excellent results after the implantation in younger patients [3, 4]. There is very little information available concerning the outcome for older patients after treatment of a short hip stem. As progressive demographic processes and increased

life expectancy create an urgent need for such data, it is necessary to collect long time results for evidence of short hip stems in older patients. One important requirement for a successful implantation of a cementless hip prosthesis is bone quality [5]. With increasing age, bone mass density decreases (BMD) [6]. Jones et al. described a continuous decrease of BMD for both sexes from 60 years of age onward [7]. Aseptic loosening and early revision are two of the most frequent long-term complications [8]. In addition, the patients' expectations toward surgery have changed. Even older patients aim for more mobility, freedom from pain and a greater durability of their prosthesis [9]. In case of a possible revision surgery remaining bone structure is an important factor [10]. The number of revision surgery has raised [11] and the complications after a revision THA increases with age [12]. Cementless short hip stems are designed to support a bone structure saving implantation and to realize a physiological load initiation [13]. The minimal invasive

✉ Bernd Alexander Ishaque  
Bernd.Ishaque@ortho.med.uni-giessen.de

<sup>1</sup> Department of Orthopaedics and Orthopaedic Surgery, University Hospital Giessen and Marburg (UKGM), Klinikstraße 33, 35392 Giessen, Germany

<sup>2</sup> Laboratory of Biomechanics, Justus-Liebig-University Giessen, Klinikstraße 29, 35392 Giessen, Germany

approach is chosen in most cases as there is less damage of muscle and soft tissue during surgery. Rehabilitation and mobilization benefit from the minimal invasive approach [10]. Patients can earlier put strain on their hip and recover faster.

A previous study [13] which was also undertaken by our institute implied a correlation between age and changes of the BMD. Therefore, the aim of this study was carried out to examine this context regarding a younger ( $\leq 59$  years) cohort with an older ( $\geq 60$  years) cohort after treatment of a short hip stem. For this purpose the clinical Harris Hip Score (HHS) was raised and dual energy X-ray (DXA) and radiological measurements were utilized. The first hypothesis states that there is a significant difference of BMD remodeling changes in regions of interest (ROI) 1–7 after 24 months comparing younger and older cohort. The second hypothesis suggests evidence for poorer results in the older cohort regarding the radiological measurements in contrast to the younger cohort. The third hypothesis indicates that the HHS differs significantly for both groups after 24 months.

## Patients and methods

### Demographic data

From March 2010 to July 2014, 67 patients were recruited at the Department of Orthopaedics and Orthopaedic Surgery at the University Hospital Giessen and Marburg (UKGM). After the successful unilateral implantation of the Metha<sup>®</sup> short hip stem the patients were examined (Ethical commission file number: 152/09). Patients with diagnoses primary or secondary coxarthrosis, hip dysplasia and femoral head necrosis were included. The exclusion criteria were incomplete follow-up, no agreement for the study and any operations on the other hip during 24 months. In the younger cohort 39 patients were under 60 years ( $50.9 \pm 6.4$ , range 33–58) and in the older cohort 28 were over 60 years old ( $66.3 \pm 5.5$ , range 60–78). In the older patients group 16 patients (57.1%) were male and 12 patients (42.9%) female. In the younger patient group 13 patients (33.3%) were male and 26 patients (66.7%) female. The body mass index (BMI) was  $28.24 \pm 4.91$  kg/m<sup>2</sup> (range 19–39) for the younger collective and  $26.77 \pm 4.69$  kg/m<sup>2</sup> (range 18–37) for the older collective. In the younger cohort, 19 patients (48.7%) had a surgery at the left hip joint and 20 patients (51.3%) were treated at the right hip joint. In the older cohort nine patients (32.1%) were treated at the left hip joint and 19 patients (67.9%) at the right hip joint.

### Implants

The cementless Metha<sup>®</sup> (BBraun, Aesculap, Tuttlingen, Germany) short hip stem prosthesis is designed for realizing a multipoint anchoring in the metaphysis and the proximal diaphysis. The prosthesis is made of a titanium forged alloy (Ti6Al4V/ISO 5832-3) and has a dicalcium phosphate layer. All patients were supplied with the monobloc version of the Metha<sup>®</sup> prosthesis.

### Surgical technique

The surgery was performed by two experienced surgeons. The first surgeon (B.A.I.) performed 65 surgeries and the second surgeon (O.B.) performed two surgeries. X-ray stencils were used for the preoperative planning of the surgery. The minimal invasive anterolateral approach according to Frndak et al. [14] was chosen for 65 patients. In two cases, the lateral approach according to Bauer [15] was used.

### Clinical and radiological examination

HHS was raised preoperative, postoperative after 3, 6, 12 and 24 months. The radiological examination was built up of DXA and radiological measurements. The Lunar Prodigy Primo and the Orthopedic Hip Software (GE Medical Systems, Madison, Wisconsin, USA) were used for the evaluation of DXA analysis. The DXA examinations took place 1 week after surgery ( $t_1$ ), after 6 ( $t_2$ ), 12 ( $t_3$ ) and 24 ( $t_4$ ) months. The first DXA scan ( $t_1$ ) was used as a reference for the following examinations. The periprosthetic bone was divided in seven ROIs according to Gruen [16] (Fig. 1). The BMD was measured in g/cm<sup>2</sup>.

Furthermore, X-ray images of the pelvic area in a.p. (anterior–posterior) and according to Lauenstein [17] were raised for the radiological examination. These images were taken preoperatively, postoperatively and 3, 6, 12 and 24 months after surgery. MediCAD Version 4.007 (medCad Hectec GmbH, Altdorf bei Landshut) was used for the examination of radiological measurements.

The radiographs were calibrated by the prosthetic head size, a standardized lead ball or a magnification factor of 1.15. The radiological examination was performed by one investigator. The parameters of the radiological examination were stress shielding according to Engh [18], calcar rounding, reactive lines, spot wells and sclerosing according to Engh [18].

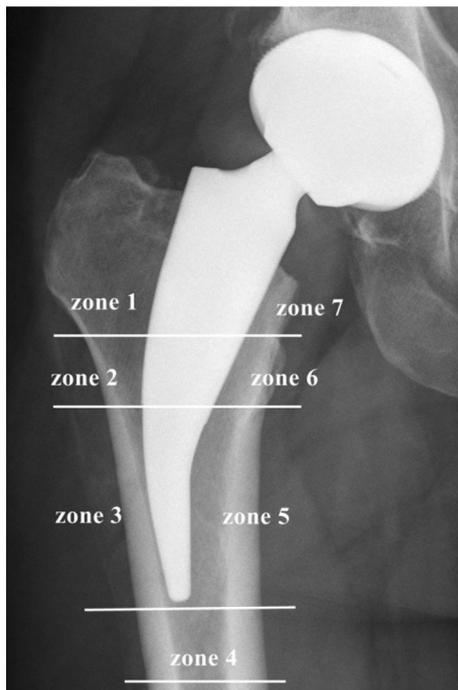


Fig. 1 ROIs according to Gruen

**Statistics**

Statistical analyses were performed using SPSS 24.0 (IBM Corporation, New York). A multifactorial variance analyses (MANOVA) with repeated measurements such as descriptive evaluation were performed. A *p* value of <0.05 was determined as statistically significant.

**Table 1** HHS measurement results preoperative, after 3, 6, 12 and 24 months

Group	HHS preop	HHS 3 months	HHS 6 months	HHS 12 months	HHS 24 months
≤59	53.6±8.2	88.8±10.3	91.7±11.7	93.0±8.8	93.2±9.6
≥60	57.6±14.8	89.4±9.6	93.0±9.8	96.1±7.2	94.1±7.6

**Table 2** BMD measurement results of ROIs 1–7 (g/cm<sup>2</sup>) for the younger cohort ≤59 and the older cohort ≥60 years with absolute and relative changes of BMD

Gruen zone	t <sub>1</sub>		t <sub>2</sub>		Percent (%)		t <sub>3</sub>		Percent (%)		t <sub>4</sub>		Percent (%)	
	BMD (g/cm <sup>2</sup> )		BMD (g/cm <sup>2</sup> )		Percent (%)		BMD (g/cm <sup>2</sup> )		Percent (%)		BMD (g/cm <sup>2</sup> )		Percent (%)	
	≤59	≥60	≤59	≥60	≤59	≥60	≤59	≥60	≤59	≥60	≤59	≥60	≤59	≥60
ROI 1	0.79	0.87	0.71	0.79	-10.18	-9.37	0.73	0.80	-7.64	-8.87	0.74	0.81	-5.92	-7.29
ROI 2	1.42	1.54	1.36	1.6	-3.53	+4.01	1.42	1.52	-0.09	-0.28	1.39	1.50	-1.45	-2.05
ROI 3	2.13	2.17	2.08	2.25	-1.71	+3.95	2.12	2.21	-0.37	+2.06	2.16	2.19	+1.75	+1.42
ROI 4	2.06	2.14	2.04	2.03	-0.4	-4.79	2.02	2.03	-1.49	-4.7	2.06	2.00	+0.07	-5.95
ROI 5	1.91	1.97	1.88	1.94	-0.97	-1.8	1.88	1.94	-0.86	-1.82	1.91	1.91	+0.81	-3.17
ROI 6	1.42	1.44	1.43	1.48	+1.99	+3.56	1.44	1.51	+2.08	+4.65	1.46	1.57	+3.30	+9.28
ROI 7	1.31	1.43	1.18	1.26	-9.45	-10.03	1.15	1.25	-13.01	-11.04	1.19	1.32	-7.70	-6.29

**Results**

**Clinical results**

The HHS improved from 53.6 ± 8.2 preoperative to 93.2 ± 9.6 after 24 months for the younger patients. For the older patients, the HHS raised from 57.6 ± 14.8 to 94.1 ± 7.6. A significant difference between the two groups could not be detected, but the improvement from preoperative to the 3 months follow-up was significant for each cohort group (*p* ≤ 0.001) (Table 1).

**Osteodensitometrical results**

BMD atrophy could be detected after 24 months in ROI 1 (-5.92%), ROI 2 (-1.45%) and ROI 7 (-7.70%) for the younger group. BMD progression could be noticed in ROI 3 (+1.75%), ROI 4 (+0.07%) ROI 5 (+0.81%) and ROI 6 (+3.30%). For the older group there was a loss of BMD in ROI 1 (-7.29%), ROI 2 (-2.05%), ROI 4 (-5.95%), ROI 5 (-3.17%) and ROI 7 (-6.29%). BMD hypertrophy could be seen in ROI 3 (+1.42%) and in ROI 5 (+9.28%) for the older patients. A significant loss of BMD took place in ROI 1 in the period between t<sub>1</sub> and t<sub>2</sub> in both groups (*p* ≤ 0.001) (Table 2).

**Radiological results**

Reactive lines could be detected in ROI 4 most frequently. Most of the spot welds were located in ROIs 2 and 6. Sclerosing was accumulated in ROI 4. During the radiological

examination two patients of the older group were excluded because of a missing radiograph image (Table 3).

No calcar rounding and no stress shielding were detectable in both groups after 3 months. After 24 months calcar rounding could be detected at 30 patients of the younger group. In the group of older cohort 23 patients with calcar rounding were noticed. Stress shielding could be detected in both groups after 24 months. Stress shielding scale 1 was detected at 21 younger patients and 15 older patients. Stress shielding scale 2 was observed for 12 patients of the younger cohort and for nine patients of the older cohort.

### Discussion

There are a lot of studies focusing on osseointegration and clinical examination of the Metha<sup>®</sup> short hip stem prosthesis [1, 3, 13, 19, 20]. The prosthesis is well studied according to long-term results and as a perspective for younger patients. This is the first study comparing results after short stem implantation between older and younger patients focusing on the outcome of older patients. The methods of the study are established. The HHS is an established score system to capture quality of life after THA [21–23]. Dual energy X-ray absorptiometry is a precise method to analyze bone quality [24]. Analyzing of Gruen zones is a proven method to evaluate bone remodeling changes or aseptic loosening [25]. Brodner et al. reported that the factor age has a significant impact of ROI 1 and ROI 4 [26]. Other authors did not find a correlation between age and changes of bone density [27, 28]. Our study has shown different but not significant results for the two groups.

A few studies could show that older patients benefit from a total joint replacement. The quality of life was improved and also the reduction of pain [29, 30]. Fang et al. described a similar improvement in quality of life after THA for older patients compared to younger patients [31].

The first hypothesis of this study was that significant changes of BMD in ROIs 1–7 could be detected after 24 months comparing the younger and the older cohort. Our analysis reveals no significant differences between the two groups. BMD decreased in both groups in the region of the greater Trochanter and the calcar probably caused by stress shielding. Decrease of BMD around the greater Trochanter caused of stress shielding is a comment found in the literature [32, 33]. Our results show that for both groups a loss of BMD in ROI 7 could be detected. Loss of BMD in ROI 7 is known as a consequence of stress shielding in the proximal region of the femur [34]. However, lower losses and higher growths of the BMD except in ROI 6 and 7 in the younger cohort indicate a better osseointegration of the prosthesis in the younger patients of our study. These results could be influenced by earlier rehabilitation [3], fewer comorbidities

**Table 3** Radiological examination of the Gruen zones after 3, 6, 12 and 24 months of the younger cohort  $\leq 59$  compared to older cohort  $\geq 60$

Gruen zone	Reactive lines						Spot welds						Sclerosing											
	3 months		6 months		12 months		24 months		3 months		6 months		12 months		24 months		3 months		6 months		12 months		24 months	
	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$	$\leq 59$	$\geq 60$		
ROI 1	-	-	1	2	1	2	5	4	-	-	2	7	-	-	1	-	-	-	-	1	-	-	2	2
ROI 2	-	-	-	-	-	1	1	1	1	1	2	7	3	10	6	-	-	-	-	-	-	-	1	-
ROI 3	-	-	-	-	1	1	1	3	-	-	-	-	2	1	-	-	-	-	-	-	-	2	1	2
ROI 4	-	-	9	5	20	14	24	16	-	1	-	1	-	-	-	1	7	5	8	-	7	5	8	6
ROI 5	-	-	-	-	4	1	7	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
ROI 6	-	-	-	-	-	-	1	1	-	6	4	12	12	17	15	-	-	-	-	-	-	1	-	-
ROI 7	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	-	-	-	-	-	-	-	-	-

[31], less postoperative complications [31], better bone quality and quantity [6] in younger patients. Fang et al. found a significant increasing rate of mortality and myocard infarction after total joint hip arthroplasty in the elderly. He also reported a higher comorbidity rate in elderly patients [31].

The second hypothesis was that the older cohort has poorer results regarding the radiological measurements in contrast to the younger cohort. This hypothesis could not be confirmed. In both groups reactive lines, spot welds and sclerosing could be noticed. The majority of reactive lines were located in ROIs 3, 4 and 5 in both groups. These zones correspond to the uncoated parts of the prosthesis. Reactive lines in this area cannot be interpreted as a sign of instability [18]. The detected reactive lines in ROIs 1, 2 and 6 correspond to the coated part of the stem. This could be a sign of inadequate osseointegration of the prosthesis. No evidence of poor osseointegration was found in the clinical examination. There was no revision surgery in the entire collective. Most of the spot welds were located in ROIs 2 and 6 and are a sign for adequate osseointegration [18]. Calcar rounding was detected in both groups in the 24 months follow-up which is a sign of quantitative atrophy of bone. Our DXA evaluation does not confirm this result. It seems like the quality of bone improves according to DXA evaluation, but the quantity of bone is decreasing according to the X-rays. If DXA examination, which is established as the gold standard for osteoporosis validation [25], is suitable for examining the quantitative as well as the qualitative measurement of BMD changes in periprosthetic bone—especially in zone 7—should be examined in further studies.

The third hypothesis indicated that the HHS was significantly different for both groups after 24 months. In addition, this hypothesis could not be proven. The HHS raised significantly in the period from preoperative to the 3 months follow-up for both groups. However, no significant difference between the two groups could be detected. In the 24 months follow-up the HHS is  $93.2 \pm 9.6$  in the younger cohort and  $94.1 \pm 7.6$  in the older cohort. This result indicates a similar quality of life after THA in both groups.

One limitation of our study consisted in the unbalanced sex distribution of our groups and the different numbers of patients in the two groups. The time of follow-up (24 months) can be elongated so that we get more long time results for older patients with a cementless hip prosthesis. In addition, a multi-centered study would contribute to the validation of our results.

The indication for a cementless hip prosthesis should not only focus on the aspect age. There are lots of factors which are important for the indication of hip replacement surgery. Pain, function, radiological changes, failed conservative therapy are some of them [28, 35]. Another important element for adequate osseointegration is bone quality [36]. Our study could show adequate osseointegration for the entire

collective. This result could be substantiated by a previous study [13] which was also undertaken by our institute.

## Conclusion

In our study, we could not detect any significant differences or any influences of osseointegration and clinical outcome of the Metha<sup>®</sup> short hip stem for both groups. Summing up, lower losses (ROIs 1 and 2) and higher growths (ROIs 3, 4, 5) were discovered in younger patients. The HHS improved in both groups. Reasons for this result could be age, sex or the level of activity of the patients, but in both groups the Metha<sup>®</sup> prosthesis shows comparable results in clinical as well as in radiological examination. The Metha<sup>®</sup> prosthesis seems to be an adequate treatment for THA also for older patients. Further studies could be carried out to examine potential cofactors like sex, socioeconomic status and level of activity.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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