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Research Article

Subsidence Analysis of the Metaphyseal Fixed Shorter Cementless CoreHip Stem

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Abstract

Background: Stem subsidence is a predictive factor for early aseptic loosening of hip implants. This study aimed to analyze the subsidence of the metaphyseal-anchored shorter CoreHip stem and investigate possible influencing factors.

Methods: A total of 100 patients (61 female, 39 male; mean age 65.4±9.8 years) undergoing primary THA with CoreHip stems (2020–2025) were analyzed. Radiographic migration was assessed with FXA software at 5 days, 3 months, and 24 months postop. Clinical variables (age, BMI, weight, gender) and radiographic parameters (Dorr type, Canal Fill Ratio, Canal Flare Index, stem angulation, stem size) were evaluated.

Results: Mean subsidence was 1.03±1.56 mm at 3 months and 1.39±1.87 mm at 2 years. Subsidence >2 mm occurred in 14% of cases. Higher BMI was significantly associated with greater subsidence, while weight was not. Dorr type A femora were more frequent in the ≤2 mm subsidence group. No radiolucencies >2 mm or aseptic loosening were observed. No intraoperative or postoperative complications occurred. Subsidence did not significantly differ between stem sizes.

Conclusion: The CoreHip stem demonstrated comparable or lower subsidence than other short stems. Higher BMI was linked to increased subsidence, whereas weight was not. The small Dorr C sample size remains a limitation.

Keywords: CoreHip; Prosthetic Stem; Subsidence; Total Hip Replacement

Introduction

Aseptic loosening is the most common cause of failure of Total Hip Arthroplasty (THA) and for cementless THA it is already the case 6 months after implantation [1-3]. Subsidence (distal migration of the femoral stem) has shown to be a good predictive factor for early aseptic loosening of this implant [4-7]. Krismer et al. [6] determined a threshold of 1.5 mm subsidence for cementless and cemented stems within the first two years as a well-established risk factor for early implant failure and Streit et al. [4] rated a limit of 2.7 mm as critical for the cementless CLS-stem (ZimmerBiomet, Winterthur, Switzerland). The maximum of subsidence occurs within the first 6 - 12 weeks postoperatively [8-12] as bony ingrowth takes place up to 4 – 12 weeks [13,14]. After 24 months stabilization of subsidence is observed in several studies [11,14,15]. The risk of subsidence of a femoral stem is

reported to be between 5 and 61.5 % [17]. Femoral stem design and type as well as anatomical properties play relevant roles for the occurrence of subsidence [8,10,18]. A close proximal fit of the femoral stem in the femoral canal is important for initial torsional stability of the stem [18-20], which improve bony ingrowth of the implant [21-24]. The Canal Fill Ratio (CFR) and Canal Flare Index (CFI) are common parameters to describe the stem anchorage in the femoral canal [8,25].

The CoreHip (Aesculap AG, Tuttlingen, Germany) is a new cementless tapered titanium-stem with metaphyseal anchorage and shorter stem length compared to traditional stems. The CoreHip system is a prosthetic stem system in which each size has three different femoral neck-shaft angles (Varus 122°, Standard 132°, Valgus 142°) (Figure 1). These can all be implanted with one rasp of the corresponding size. The aim of the current study was to analyze the quality of the proximal fixation of this shorter stem using subsidence analysis and to evaluate which factors influence a possible subsidence.

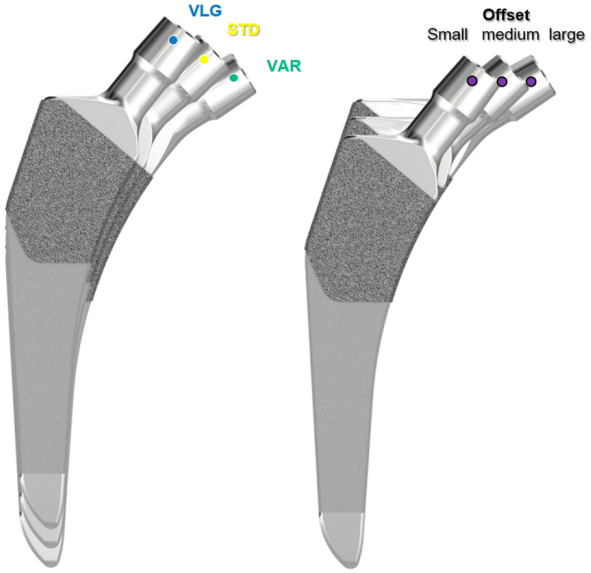

Figure 1: Setting of three different offsets for the same stem size and leg length in the CoreHip-System

Materials and Methods

100 Patients (61 female, 39male) with unilateral CoreHip cementless stems (performed in 2021) were followed prospectively for 2 years. Exclusion criteria were revision cases, infection and bilateral implantations. The age of the patients was 65.4 ± 9.8 years (24 – 84 years) and the BMI 27.3 ± 3.8 (20.5 – 38.5). All surgeries were performed at a single institution by three experienced surgeons using a posterolateral approach. Postoperative full weight-bearing was allowed from day one. Stem size distribution is shown in Table 1.

Stem size	Number of cases (n)
1	6
2	6
3	14
4	21
5	23
6	20
7	6
8	3
9	1
Total	**100**

Table 1: Distribution of stem sizes

Hip stem migration (subsidence) was evaluated on anterior-posterior radiographs of the pelvic in a standing position with a film-focus-distance of 115 cm performed 5 days, 3 months and two years postoperative. The validated software "FXA" of the independent imaging core lab (RAYLYTIC, Leipzig, Germany) was used [26-28]. The software matches two images (24 months and 3 months vs. 5 days postop) using a normalized 2D grayscale cross-correlation algorithm in an iterative process using the evolutionary optimization algorithm CMA-ES [29]. Moreover, the radiographs were analyzed for radiolucent lines around the stem. The radiographs were analyzed retrospectively. The following parameters were measured on the postoperative radiographs (Figure 2,3): The Canal Flare Index (CFI), the Canal Fill Ratio (CFR), the Stem Angulation (SA) and calculated as potential influencing factors for subsidence as well as the clinical parameters: gender, weight, BMI, age and stem size.

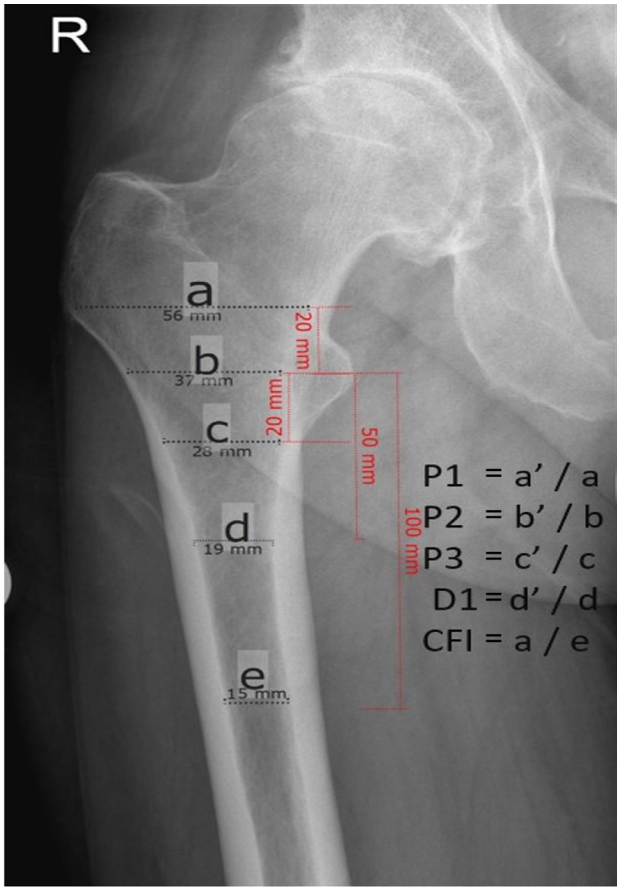

Figure 2a: Description of the different measurements for calculating the Canal Fill Index (CFI) and Canal Fill Ratio (CFR). Fig 2a: preoperative x-ray, Fig 2b: postoperative x-ray. Canal Flare Index (CFI = a/e), Canal-Calcar Ratio (CCR = e/b); Canal Fill Ratios (CFR P1) at 2 cm above the lesser trochanter (P1 = a'/a), CFR P2 at the lesser trochanter (P2 = b'/b), CFR P3 at 2 cm below the lesser trochanter (P3 = c'/c), CFR D1 at 5 cm below the lesser trochanter (D1 = d'/d).

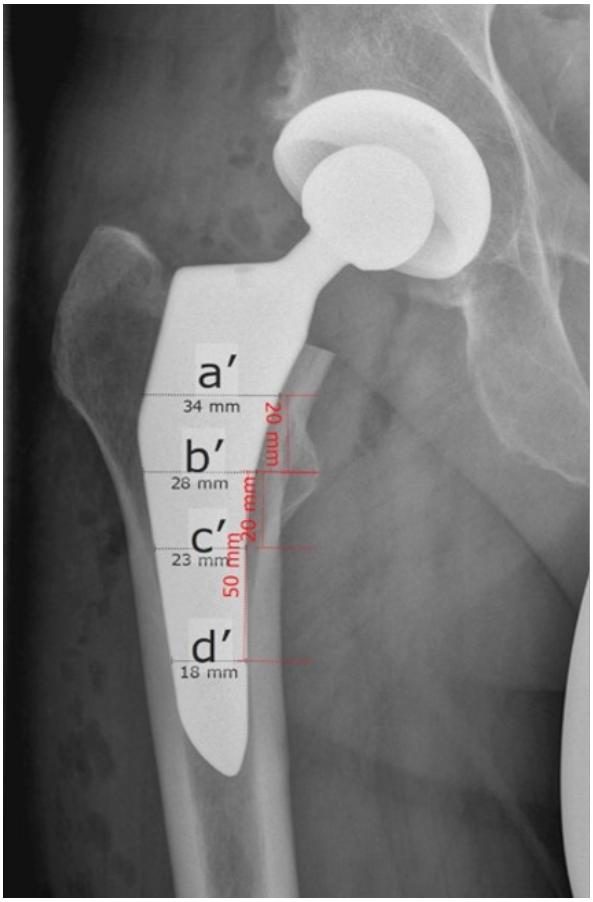

Figure 2b: Description of the different measurements for calculating the Canal Fill Index (CFI) and Canal Fill Ratio (CFR). Fig 2a: preoperative x-ray, Fig 2b: postoperative x-ray. Canal Flare Index (CFI = a/e), Canal-Calcar Ratio (CCR = e/b); Canal Fill Ratios (CFR P1) at 2 cm above the lesser trochanter (P1 = a'/a), CFR P2 at the lesser trochanter (P2 = b'/b), CFR P3 at 2 cm below the lesser trochanter (P3 = c'/c), CFR D1 at 5 cm below the lesser trochanter (D1 = d'/d).

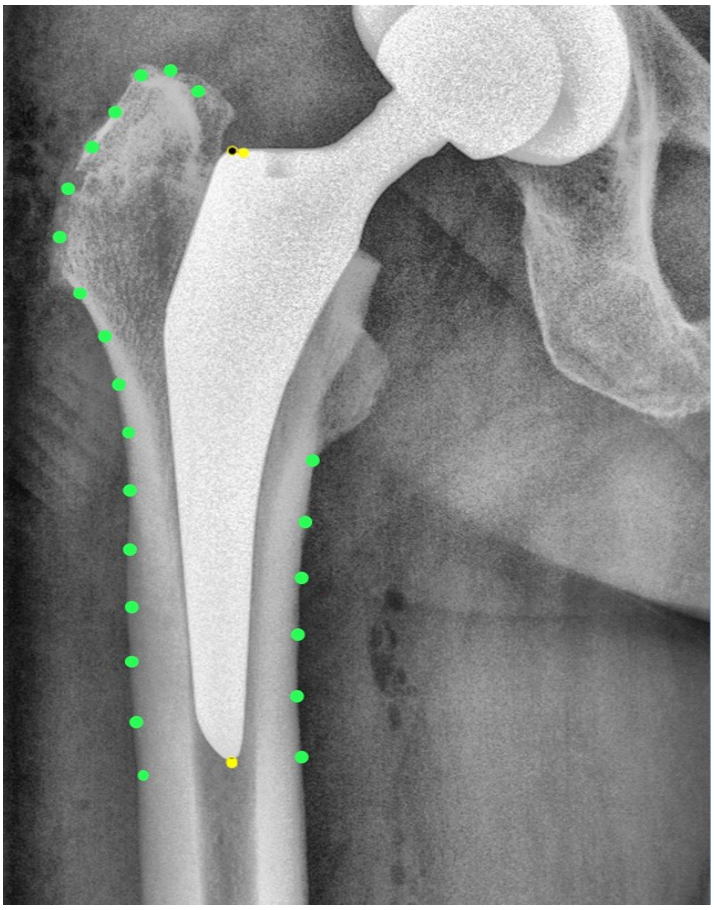

Figure 3a: Case example with FXA software to analyze the subsidence. Fig. 3a: five days postoperative, Fig. 3b: two years postoperative

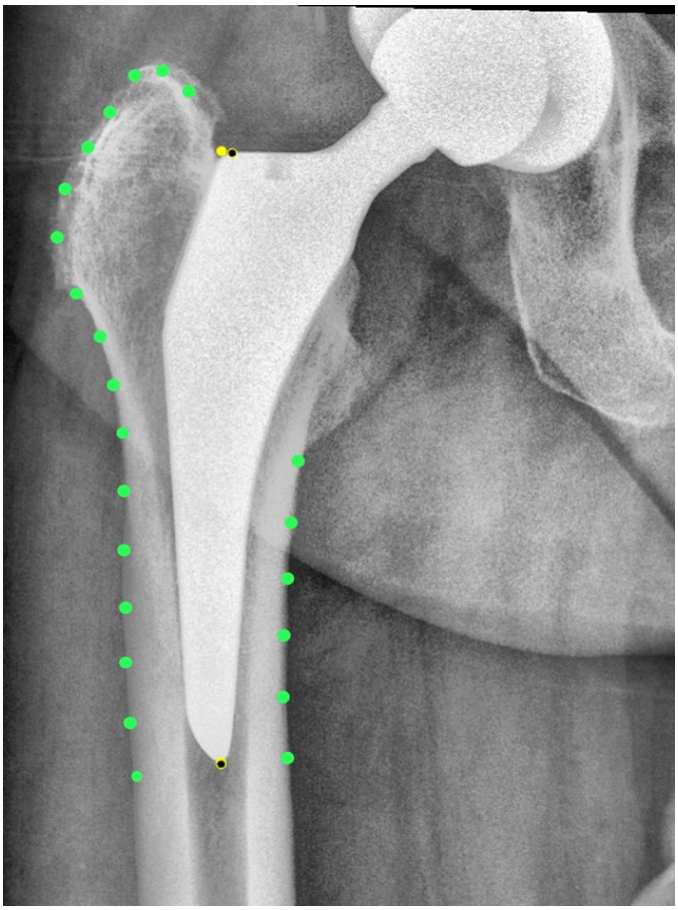

Figure 3b: Case example with FXA software to analyze the subsidence. Fig. 3a: five days postoperative, Fig. 3b: two years postoperative

Statistical analysis:

Statistical analysis was performed using IBM SPSS Statistics for Windows (version 24, IBM Crop., Armonk, NY). For statistical evaluation of categorial variables and group comparisons, Chi-square and Fisher's exact test were used. For statistical evaluation of parametric data, a Student t-test was used; for nonparametric data, a Mann-Whitney U-test was used. All reported p-values are two-tailed, with an alpha level < 0.05 considered as significant. All values are either given as mean ± standard deviation or median and interquartile range.

Results

The average subsidence was 1.03 ± 1.56 mm at 3 months and 1.39 ± 1.87 mm at 2 years follow-up. In 14 % there was a subsidence of more than 2 mm. Of the possible influencing parameters only BMI and Dorr-type showed a significant difference between stems with less or more than 2 mm subsidence (higher BMI in patients with more than 2 mm subsidence and higher amount of Dorr-type A femurs in the group of femurs with less than 2 mm subsidence) (Table 2,3). All other clinical and radiological parameters showed no difference between the two groups (less and more of 2 mm subsidence) (Table 2,3) We did not observe any early aseptic loosening nor radiolucency of more than 2 mm in the follow-up of this study. No revision was performed in the follow-up.

	Subsidence ≤ 2mm	Subsidence > 2mm	p-value	Test
Side				
Left	34	3	0.265	Fisher's exact test
Right	53	10		
Gender				
female	50	11	0.61	Fisher's exact test
male	37	2		
Dorr-Type				
A	9	0	**< 0.001**	Chi-square
B	72	7		
C	6	6		

Table 2: Categorical variables

	Subsidence ≤ 2mm	Subsidence > 2mm	p-value	Test
BMI	27.0 ± 4.0	29.2 ± 2.2	**0.009**	T-test
Age	65.4 ± 10.0	65.2 ± 9.3	0.911	T-test
Weight	79.5 ± 14.1	82.2 ± 10.7	0.43	T-test
Axis [varus: positive, valgus: negaitve]	0.6° ± 1.0°	0.3° ± 0.7°	0.156	T-test
CFI	3.2 ± 0.6	3.2 ± 0.9	0.92	T-test
CFR P1	0.71 ± 0.06	0.73 ± 0.06	0.285	Mann-Whitney-U
CFR P2	0.78 ± 0.08	0.79 ± 0.05	0.685	Mann-Whitney-U
CFR P3	0.80 ± 0.08	0.80 ± 0.05	0.785	Mann-Whitney-U
CFR D1	0.80 ± 0.08	0.80 ± 0.05	0.787	T-test

Table 3: Interval scaled variables

Discussion

Different thresholds of subsidence for prediction of aseptic loosening have been described in the literature [4,6]. Krismer et al. [6] determined a threshold of 1.5 mm subsidence for cementless and cemented stems within the first two years as a well-established risk factor for early implant failure with a sensitivity of 69 % and a specificity of 80 % and Streit et al. [4]. rated a limit of 2.7 mm as critical for the cementless CLS-stem (ZimmerBiomet, Winterthur, Switzerland). Freeman and Plante-Bordeneuve [30] described a threshold subsidence of 1.2 mm per year during the first 2 years for the prediction of aseptic failure with a specificity of 86% and a sensitivity of 78%. Stihlsen et al. [31] found a highly significant correlation of subsidence > 2 mm at 2 years and subsequent aseptic loosening for the proximally fixed cementless Vision 2000 stem (DePuy Orthopaedics Inc., Warsaw, IN, USA). Because of that and because several other studies set the threshold of subsidence at 2 mm [12,32], we calculated the amount of patients with subsidence of more than 2 mm. For other cementless stems with comparable stem lengths similar subsidence were found as in the current study. Freitag et al. [14] reported an average subsidence of 1.1 mm (range: -5mm to 1.5 mm) up to 5 years follow-up for the Fitmore stem (ZimmerBiomet, Winterthur, Switzerland), Schader et al. [33] of 1.6 ± 1.6 mm and Wanner et al. [34] of 1.4 ± 1.4 mm for the same stem after one year follow-up. Hasler et al. [12] observed an average stem subsidence of 1.98 ± 1.2 mm at a minimum follow-up of 5 years for the AMIStem (Medacta International, Switzerland). Dammerer et al. [35] found a mean subsidence of 1.4 mm (range 0.0-12.0 mm) after 2 year-follow-up of the metaphyseal-anchored press-fit stem Accolate II (Stryker, Kalamazoo, MI, USA) and Migliorini et al. [36] a mean subsidence of 2.8 ± 0.7 mm after 14.1 ± 10.8 months for the collarless Corail stem.

14 % of the CoreHip stems in the current study had a subsidence > 2mm at the follow-up of 2 years. In the study of Hasler et al. [12] 48% of the AMIStems had a subsidence of more than 2 mm at the latest follow-up. Gustke [32] observed a subsidence > 2 mm in 34 % of 100 Fitmore stems (ZimmerBiomet, Warsaw, IN, USA) after a mean follow-up of 1.3 years and Dammerer et al. [35] a subsidence of > 1.5 mm in 28.2% and of > 2.7 mm in 14.1 % of 64 Accolate II stems (Stryker, Kalamazoo, MI, USA) after two years follow-up. Radiolucency of more than 2 mm was not seen in the current study. In the study of Hasler et al. [12] 26% of the AMIStems (Medacta Intrnational, Switzerland) had a radiolucency of more than 2 mm at the latest follow-up of 5 years and Schader et al. [33] in 17.5% for the Fitmore Stem (ZimmerBiomet, Wintherthur, Switzerland) at 10 year-follow-up.

One influencing factor for subsidence is the press-fit of the stem [37,38]. However, in the current study the Canal Fill Ration (CFR) and Canal Flare Index (CFI) as parameters for describing the stem anchorage in the femoral canal [8,25] differed not between the stems with and without subsidence of more than 2 mm. Onio et al. [39] found a significant greater subsidence in Dorr type C femurs compared to the other types for the Fitmore stem. This was not seen in our study, maybe because the sample size for Dorr type C femura was limited. However, it was seen, that stems in Dorr type A femurs were more often in the group of subsidence < 2 mm. Additionally we found a significant higher BMI in the group of more than 2 mm subsidence. BMI was identified as an influencing factor for subsidence in the study of Dammerer et al. [35], Stihlsen et al. [31] and Migliorini et al. [40], whereas Schaer et al. [11] and Hasler et al. [12] did not find clinical parameters (weight, BMI, gender, age) influencing subsidence.

This study has some limitations, including the absence of a control group and the retrospective methodology. Therefore, some selection bias cannot be ruled out completely. However, the number of patients is sufficient, similar or even larger as some other cited studies [11,12,32,33,35,39,41,42]. While RSA is considered to be the gold standard for subsidence analysis, EBRA-FCA as well as Realytics offers the advantage of being a non-invasive method with high accuracy that can be used in a retrospective study design [6,41]. Therefore, valid results can be assumed. Another limitation is the follow-up period of 24 months. The maximum of subsidence is reported to occur between 6 and 12 weeks in studies [8-12] and within the first six months in other studies [16,42]. After 24 months stabilization of subsidence is observed in several studies [11,14,15,35]. Moreover, other studies concerning stem subsidence had the same follow-up [9,43,44].

Conclusion

The examined CoreHip stem showed comparable or even lower subsidence to other stems on the market with higher BMI in the patients with subsidence of more than 2 mm and more often Dorr A types in the femora with less than 2 mm subsidence.

Acknowledgments

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Ethical Considerations

This study was approved by the Ethics Committee of the Landesärztekammer Baden-Württemberg (Ref. F-2017-085). All patients provided informed consent. Consent for publication of radiographic images was obtained.

Conflict of Interest

B.F. is a consultant of Aesculap, Tuttlingen, Germany. M.S. is an employee of Aesculap, Tuttlingen, Germany. Other authors declare no conflicts of interest.

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Authors' Contributions

BF and MM contributed equally as first authors. BF and MM analyzed and interpreted the data, wrote the article. BF supervised the study. MM was responsible for sample analysis. PS performed statistical analysis. All authors approved the final manuscript.

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