

**Development of early complications after treatment of trochanteric fractures
with an intramedullary sliding hip screw in a geriatric population**

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Development of early complications after treatment of trochanteric fractures with an intramedullary sliding hip screw in a geriatric population

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Abstract

Purpose Although trochanteric fractures (TF) are a frequent event in the geriatric population, studies reporting on complication rates associated with surgical treatment are sparse. Thus, this study investigated the relevance of fracture-, implant-, and surgery-associated complications in TF. Furthermore, the role of possible risk factors for the before mentioned complications was investigated.

Methods A consecutive series of patients with TF treated by intramedullary nailing with a sliding screw device was evaluated. Data were sampled retrospectively from the hospital patient information system and anonymized at the source. Demographic data and information regarding fracture pattern, the treatment performed, hospital stay, and evaluation of operative and follow-up radiographs were analyzed. Intraoperative problems (i.e., technical problems with the implant, intraoperative fracture) and postoperative complications were investigated.

Results Postoperative surgical complications were noted in 11.7%. The most frequent surgical problem was a difficult fracture reduction (13%) and intraoperative fracture dislocation (3.6%). The most frequent postoperative complication was intra-hospital mortality (3.6%), delayed/non-union (2.7%), and a cut-out of the lag screw in the femoral head (2.3%). Implant failure (1.4%) was significantly associated with morbid obesity while cut-out (2.3%) correlated with a higher tip–apex distance (TAD). A complex fracture type and a suboptimal screw position significantly increased the cut-out rate to 5% ($p=0.018$).

Conclusion Complications after TF treatment occur frequently. While patient-associated variables such as morbid obesity cannot be influenced by the surgeon, correct fracture reduction and implant positioning remain to be of highest importance.

Keywords Early complications · Trochanteric fracture · Hip screw · Geriatric

Introduction

Trochanteric fractures (TF) represent a common injury in daily trauma care. Disability, increased mortality, and reduced quality of life are strongly associated, and thus represent a major burden to health systems [5, 40]. TF are most often seen in elderly patients with decreased bone quality. Mattisson et al. showed in a study including 10,548 patients that the absolute majority of the trochanteric and

subtrochanteric hip fracture patients are fragile patients with a tendency to fall. With advanced age, there is an increased risk for suffering from a hip fracture even after a low energy fall. Aside age and osteoporosis, living alone, smoking, and combined diabetes are independent risk factors for TF [33] which further increase morbidity and mortality [7].

Treatment of TF is typically performed via operative stabilization. Depending on fracture pattern, trochanteric nails, dynamic hip screws, or sometimes arthroplasty is performed. Regarding trochanteric nails, Wessels et al. showed that especially for more complex fracture types, intramedullary (IM) nailing allows swift treatment and provides a good outcome [39]. These results are confirmed by others [14, 27]. The influence of the postoperative tip–apex distance (TAD) [1] on the occurrence of surgical complications has been previously highlighted [30].

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While studies reporting on outcome solely focus on mortality, assessing pre-existing medical comorbidities [23], implant-related research often focuses on fracture morphology or surgical techniques [13, 42]. However, the incidence of intraoperative surgical problems, postoperative complications, and possible influencing factors is not well investigated [14, 34, 38].

In need for a better characterization of intraoperative surgical problems and postoperative complications as well as possible influencing factors contributing to the development of complications in TF, this study evaluates the occurrence of patient, fracture-, implant-, and surgery-associated complications in a large group of geriatric patients with TF and determines possible influencing factors.

Materials and methods

The study period was between January 2008 and December 2015. Treatment was performed at University Hospital RWTH Aachen (anonymized: university hospital, trauma level center 1), acting as the local referral center. Inclusion criteria were an age above 70 and an admission for the primary treatment of a TF. Data were sampled retrospectively from the hospital patient information system and anonymized at the source. Included were demographic data and information regarding fracture pattern, the treatment performed, hospital stay, and evaluation of postoperative and follow-up radiographs, as well as documentation of intraoperative problems and postoperative complications. Although surgeries were not performed by the same surgeon, all surgeons passed their residency and were approved consultants.

Treatment

Fluoroscopy guided surgery was performed on a traction table under spinal anesthesia whenever feasible. The used implant was the Gamma Hip Fractur Nailing System (© Stryker 1998–2022). Full weight bearing mobilization was performed under physical therapy guidance on day 1. Postoperative radiographs were performed, usually on day 1 or 2. Referral to geriatric rehabilitation was only sought if patients had deficiencies at discharge that excluded them from being discharged to their previous living situation.

Complications

Surgical complications were extracted and sampled as intraoperative surgical problems (technical problems with the implant, intraoperative fracture, non-anatomical fracture reduction, intraoperative fracture dislocation, problem with locking mechanism, wrong material length used) and

postoperative complications (infections, thrombosis, cut-out, delayed fracture healing (after 6 months), ipsilateral femoral or periprosthetic fracture, implant failure due to material breakage or loosening, deep infection).

Osteoporosis and Singh Index (SI)

SI was determined on the trochanteric level of the contralateral hip as described by Hauschild [16]. The trochanteric area was used, as the correlation to bone mineral density (BMD) is higher in the trochanteric area compared to the femoral neck [16, 20]. Grading was performed as follows:

- Grade 1: Even the principal compressive trabeculae are reduced in number and are no longer prominent.
- Grade 2: Only the principal compressive trabeculae are seen prominently. The others have been, more or less, absorbed.
- Grade 3: There is a break in the continuity of the principal tensile trabeculae.
- Grade 4: The principal tensile trabeculae is reduced (markedly) but still can be traced from the lateral cortex to the upper part of the femoral neck.
- Grade 5: The principal tensile trabecula is accentuated. Ward's triangle appears prominent.
- Grade 6: All trabecular groups are visible on the radiographic image. The upper end of the femur seems completely occupied by cancellous bone.

Postoperative radiographs (POR)

POR were assessed for reduction parameters (neck-shaft angle (NSA), tip–apex distance (TAD), reduction variance (RV)). Radiographic measurements for blade tip migration and telescoping from the lateral cortex were measured following the description of Paul et al. [32]. Non-union was determined at follow-up radiographs using the RUSH score [9, 32] as described by Chiavaras, with a 30-point maximum value indication of complete fracture healing [6]. A threshold score of < 18 at 6 months postoperatively has been associated with a 100% specificity (95% CI 97–100%) and a positive predictive value of 100% (95% CI 73–100%) for radiographic non-union [9]. The last available radiograph was evaluated. Follow-up ended with the last recognized X-ray, which was taken in average after 318 days ± 93 days after the operation but at least 181 days after the operation.

Statistical evaluation

Data were stored in MS Excel (v16.6, Microsoft, Richmond, USA) and statistical calculations were performed

in R (Version 4.2.1, R Core Team, Vienna, Austria). The data were evaluated using non-parametric Wilcoxon rank sum and Fisher's exact tests. The level of significance was set to $\alpha = 0.05$.

Results

Demographic data

Data from 1293 patients with a TF were detected in the institution database within the timeframe. Of these, patients who were treated with open reduction or cerclages and patients who received treatment with a different implant (i.e., intramedullary nail from a different manufacturer, dynamic hip screws, prosthesis) and finally patients with non-evaluable X-rays were excluded, thus reducing the

number of included individuals to 222 patients. Mean age was 75 ± 17 years, 135 patients (61%) were female. The majority of fractures (about 64% of cases) were classified as peri-trochanteric according to AO [26] (Table 1). The time from accident to surgery in hours could not be evaluated due to missing data of the exact time of the accident. However, all patients were operated within 2 days.

Complications

We found intraoperative surgical problems in 40 cases (18%). The most frequent problem was a difficult reduction leading to a suboptimal fracture reduction in 29 cases (13%) of which 14 (48.3%) presented with an complex A3 fracture. This was followed by dislocation of the fracture fragments after reduction and nail implantation in eight cases (3.6%). No intraoperative shaft perforation or fracture occurred in this series. Furthermore, in 4.5% of the cases, the surgeons reported on initial difficulties in placement of the guidewire which might have influenced other complications but could not be followed-up any further. All noted intraoperative surgical problems are listed (Table 2).

Postoperative surgical complications were noted in 26 patients (11.7%). Intra-hospital mortality was 3.6%. A further analysis of survival rates was not performed. A detailed analysis of all postoperative complications revealed delayed/non-union as most frequent complication (six cases, 2.7%), followed by a cut-out of the lag screw in the femoral head (five cases, 2.3%). For further details, see Table 3.

Osteoporosis

Using the initial radiograph, the SI was determined. The SI showed normal age-related values of 4–6 in 61.7% of cases, a decreased level of 3 in 33% of cases, with all others showing marked signs of osteoporosis (Table 4).

Table 1 Study characteristics

Characteristic	N	N = 222 ^a
Age at fracture	222	75 ± 17
Sex	222	
Female		135 (61%)
Male		87 (39%)
Subject weight (kg)	179	72 ± 20
Unknown		43
Subject height (cm)	179	168 ± 11
Unknown		43
BMI (in kg/m ²)	174	25.4 ± 6.3
Unknown		48
Fracture localization	222	
Pertrochanteric		141 (64%)
Subtrochanteric		47 (21%)
Intertrochanteric		11 (5%)
Mixed		23 (10%)

^aMean $\pm$ SD; n (%)

Table 2 Intraoperative surgical problems recorded in the surgical report

Characteristic	N = 222 ^a
Occurrence of intraoperative surgical problems	40/222 (18%)
Detail: intraoperative surgical problems	
Characteristic	N = 222 ^a
Non-anatomical fracture reduction	29/222 (13%)
Intraoperative fracture dislocation	8/222 (3.6%)
Intraop fracture	1/222 (0.5%)
Problem with locking mechanism	1/222 (0.5%)
Wrong material length used	1/222 (0.5%)

^an/N (%)

Table 3 Evaluation of the occurrence of postoperative complications in N = 222 patients

Characteristic	N = 222 ^a
Occurrence of postoperative complication	26/222 (11.7%)
Detail: postoperative complications	
Characteristic	N = 222 ^a
Intra-hospital mortality	8/222 (3.6%)
Delayed fracture healing	6/222 (2.7%)
Cut-out	5/222 (2.3%)
Ipsilateral femoral or periprosthetic fracture	3/222 (1.4%)
Material breakage	2/222 (0.9%)
Loosening	1/222 (0.5%)
Deep infection	1/222 (0.5%)

^an/N (%)**Table 4** Singh Index (SI) determined from preoperative radiographs at the ipsilateral trochanteric region

Characteristic	N	N = 222 ^a
Singh Index (SI)	222	
1		5 (2.3%)
2		5 (2.3%)
3		74 (33%)
4		109 (49%)
5		23 (10%)
6		6 (2.7%)
Osteoporosis (determined from SI ≤ 2)	222	10 (4.5%)

^an (%)

Postoperative radiographs (POR)

Postoperatively, the achieved caput-collum-diaphyseal (CCD) angle was compared to the uninjured side. The mean achieved CCD angle was -2° of the contralateral hip with a standard deviation of 9° . The mean TAD postoperatively was 28 mm (± 9).

To evaluate causalities for the occurrence of these complications, demographic factors, surgical quality, fracture type, and osteoporosis status were analyzed. For the development of a non-union, no statistically significant dependencies were detectable.

Influencing factors contributing to the development of complications

For the development of the postoperative complication of a cut-out (five cases), the only item that had a significant influence ($p = 0.027$) was the achieved TAD, with a mean 28 ± 9

for cases without cut-out compared to 37 ± 8 for cases where a cut-out occurred (Table 5).

In the next step, the interrelations between critical factors in cut-out complication were statistically evaluated. Complex fracture type (31-A.2 or 31-A.3), non-anatomical reduction, and suboptimal screw position as determined by a TAD > 25 mm were evaluated [32]. There was no statistically significant dependency of the cut-out rate with a complex fracture type ($p = 0.2$), non-anatomical reduction ($p = 0.6$), or high TAD ($p = 0.2$) alone. When establishing the dependencies graphically in a Venn diagram (Fig. 1), it becomes clear that 80% of patients (four cases) with a cut-out had both a complex fracture type as well as a TAD > 25 mm, with the remaining patient displaying all three characterizations. Combining all three factors, no significant difference of cut-out rate was found ($p = 0.3$).

In the population of our study, a complex fracture type and a suboptimal screw position significantly increased the cut-out rate to 5% ($p = 0.018$). All the subjects with a cut-out combined both of these factors (Fig. 1).

In case of ipsilateral femoral or periprosthetic fractures and deep infection, no significant dependencies could be found. For the postoperative complication of implant failure (three cases), morbid obesity was found to be a significant influence (Table 6). There was a trend ($p = 0.059$) of male patients sustaining an implant failure.

Discussion

TF represent a frequently seen entity in orthopedic trauma units. Despite the fact that most of the patients are older, literature reporting on complication rates associated with surgical treatment is limited. The current study, therefore, investigated complications rates and intraoperative surgical

Table 5 Statistical evaluation of the postoperative complication of cut-out

Characteristic	<i>N</i> = 222 ^a			
Cut-out	5/222 (2.3%)			
Detail: statistical comparison of subjects with/without cut-out				
Characteristic	<i>N</i>	Without cut-out, <i>n</i> = 217 ^a	With cut-out, <i>n</i> = 5 ^a	<i>p</i> value ^b
Age at fracture	222	74 ± 17	77 ± 11	> 0.9
Sex	222			0.7
Female		131 (60%)	4 (80%)	
Male		86 (40%)	1 (20%)	
BMI (in kg/m ²)	174	25.3 ± 6.3	28.8 ± 2.1	0.085
Unknown		46	2	
Fracture localization	222			0.2
Intertrochanteric		10 (4.6%)	1 (20%)	
Pertrochanteric		139 (64.1%)	2 (40%)	
Subtrochanteric		46 (21.2%)	1 (20%)	
Mixed		22 (10.1%)	1 (20%)	
Osteoporosis (determined from SI ≤ 2)	222	10 (4.6%)	0 (0%)	> 0.9
Difference between CCD angles	207	− 2 ± 9	1 ± 11	0.2
Unknown		15	0	
TAD (post-OP)	222	28 ± 9	37 ± 8	0.027*

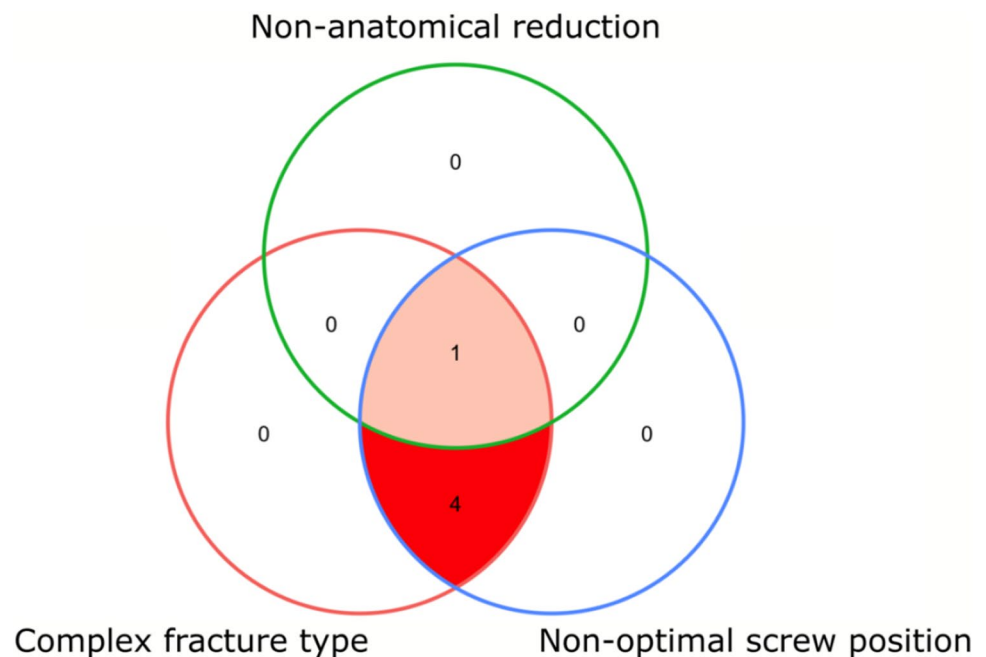
^aMean ± SD; *n* (%)^bWilcoxon rank sum test; Fisher's exact test**p* < 0.05**Fig. 1** Venn diagram of subjects with cut-out by complex fracture type, non-anatomical reduction, and suboptimal screw position (TAD > 25 mm)

Table 6 Statistical evaluation of the postoperative complications of implant failure

Characteristic	<i>N</i> = 222 ^a			
Implant failure	3/222 (1.4%)			
Detail: statistical comparison of subjects with/without implant failure				
Characteristic	<i>N</i>	Without implant failure, <i>n</i> = 219 ^a	With implant failure, <i>n</i> = 3 ^a	<i>p</i> value ^b
Age at fracture	222	75 ± 17	65 ± 12	0.13
Subject weight	179	72 ± 20	95 ± 4	0.013*
Unknown		43	0	
Subject height	179	168 ± 11	173 ± 8	0.3
Unknown		43	0	
Sex	222			0.059
Female		135 (62%)	0 (0%)	
Male		84 (38%)	3 (100%)	
BMI (in kg/m ²)	174	25.3 ± 6.3	31.7 ± 1.3	0.019*
Unknown		48	0	
Fracture localization	222			0.4
Intertrochanteric		11 (5.0%)	0 (0%)	
Pertrochanteric		140 (64,0%)	1 (33%)	
Subtrochanteric		45 (20,5%)	2 (67%)	
Mixed		23 (10,5%)	0 (0%)	
Osteoporosis (determined from SI ≤ 2)	222	9 (4.1%)	1 (33%)	0.13
Difference between CCD angles	207	− 2 ± 9	2 ± 21	0.8
Unknown		14	1	
TAD (postoperative)	222	28 ± 9	39 ± 16	0.2

^aMean ± SD; *n* (%)^bWilcoxon rank sum test; Fisher's exact test**p* < 0.05

errors in a cohort of geriatric patients with TF and the findings might be summarized as followed:

- (A) “Our data support findings by Bojan et al. that a good reduction and optimal screw position regarding the TAD is associated with lower rates of postoperative cut outs” [3]
- (B) High BMI seems to increase the risk for implant failure after treating TF with IM
- (C) “Osteoporosis did not influence the occurrence of intraoperative problems or postoperative complications when TF is treated by IM”

Demographic data

In line with other studies reporting on treatment [14, 39, 41], the detailed evaluation of a consecutive patient series treated by IM with a sliding screw, a mean age of 75 years, and a female predominance of 61% was found. Also fracture distribution was comparable to those described in larger studies

[12, 25]. Although literature regarding osteoporosis rates in TF populations is sparse, Morvan et al. described a comparable Singh Index in their study reporting on risk factors for cut-out after internal fixation of trochanteric fractures in elderly subjects [28]. Thus, this study population might be seen as representative regarding the results that will be discussed below.

Complications and surgical problems

In line with previous studies, we found the described non-anatomical fracture reduction as the leading cause for intraoperative surgical problems and complications [2–4]. Bojan et al. described 137 (4.5%) intraoperative fracture-related complications in a series of more than 3000 TF [3]. Although the scientists defined imperfect reduction not as a surgical problem but a radiological finding, they describe a non-anatomical fracture reduction in 15.3% of all cases. This also represents the difficulties in a direct comparison to other studies, as complications are most often in focus only if a revision procedure was performed [18]. Thus, intraoperative

surgical problems are not frequently assessed [35], or all surgical complications are summarized [42]. Shaft fissures or fractures have been occasionally reported in the past [10, 17] but did not occur in our study.

Regarding postoperative complications, also the detected rate in our series corresponds to the literature. Unger et al. reported of 8% [37], Bojan et al. found surgical postoperative complications in 6.2% of all cases [3]. The most often seen complication in the present study beside intra-hospital mortality was a delayed fracture healing leading to a non-union. However, this rate (2.7%) corresponds to those reported in other studies where non-unions after trochanteric fractures range between 1.8 [37] and 4.7% [15]. Although a detailed analysis of possible reasons for non-union in the present study did not provide new insights, Kristan et al. described reduced bone quality (osteoporosis), malnutrition and insufficient reduction as possible reasons [21]. In contrast to this, a detailed assessment of the osteoporosis index performed in the present study did not prove osteoporosis to be an influencing factor for non-union development. Also, for other potential reasons (e.g., quality of reduction), no statistically significant dependencies for the development of a non-union were detectable. This finding corresponds to results published by Kumar et al., who also could not find any dependencies of osteoporosis and occurrence of non-union [22].

Cut-out as a major complication that required revision surgery, occurred in 5 of 222 cases (2.3%) in our series. In a Cochrane review, Parker et al. described a cut-out in proximal femoral nails in 44 of 1376 cases (3.2%) [31]. Whereas Parker et al. did not assess the relation of obesity and the development of cut-out, a not significant trend toward higher BMI and cut-out was found in the present study. Yet, high BMI was significantly associated with material failure. Regarding BMI, Müller et al. previously described that an increased BMI in patients with TF is associated with both longer operation time and length of hospitalization [29]. Also, the authors showed inferior clinical score results. Kinder et al. showed that metal work failure and non-union is found more often in obese patients than in those with normal BMI [19]. As BMI is more often investigated in regard to social status and function rather than its association to development of material-related complications, the present study might underline this factor also in the investigated cohort.

Furthermore, cut-out of the lag screw was clearly found to be associated with insufficient reduction and malpositioning (TAD) of the screw. The present study also proved a significant correlation between insufficient reduction and malpositioning (TAD). Patients with a high TAD were more likely to sustain a cut-out. Thus, the presented findings underline previously reported data [1, 8, 11]. Bojan et al. described an influence on cut-out rates if complex fracture

type, non-anatomical reduction, and suboptimal screw position were combined [3, 4]. Also Turgut et al. found that a combination of surgeon-dependent factors, like varus reduction, implantation of the implant in the improper quadrant, and TAD complication leads to a high probability of cut-out [36]. In addition, the present study demonstrated that a complex fracture type combined with a TAD > 25 mm alone has a high predictive value for the development for cut-out.

In summary, an influence of osteoporosis on the treatment result was not found, while there appears to be an increased risk for implant failure in patients with high BMI. Moreover, related to both, complex and non-complex fracture types, results can be positively influenced by a good fracture reduction and optimal screw positioning.

Strengths and limitations

Major strength of the study is the detailed patient information gained from the hospital information system and the amount of data that could be included. Furthermore, this study illuminates an underrepresented field of interest by analyzing the occurrence of complications by IM as a frequently used technique in regard to bone quality. As a limitation of the study, its retrospective character and single-center application must be named. Furthermore, the use of SI as a marker for osteoporosis needs to be named as DEXA scan is certainly more accurate and currently the state-of-the-art technique to measure bone mineral density and to diagnose osteoporosis [24]. However, due to the emergency situation, a DEXA scan often is not feasible and SI was used as a marker and previously proven with a good inter-observer agreement for the trochanteric area [21, 28].

Another limitation of this study is the unknown long-term follow-up of most of the patients.

Conclusion

Complications after TF treatment occur frequently. In geriatric patients, a suboptimal screw position or a wrong implant length causing a high TAD significantly increases the cut-out rate. Morbid obesity has a strong influence on implant failure. While patient-associated variables such as morbid obesity cannot be influenced by the surgeon, correct fracture reduction and implant positioning remain to be of highest importance.

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Data availability The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest Author Markus Wolfgang Robioneck, Miguel Pishnamaz, Nils Becker, Eftychos Bolierakis, Frank Hildebrand, and Klemens Horst declare that they have no conflict of interest.

Ethical statement For this type of study, formal consent is not required.

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Erklärung § 5 Abs. 1 zur Datenaufbewahrung

Hiermit erkläre ich, dass die dieser Dissertation zu Grunde liegenden Originaldaten

- bei mir, Markus Wolfgang Robioneck

hinterlegt sind.

Erklärung gemäß § 5 Abs. (1) und (2), und § 11 Abs. (3) 12. der Promotionsordnung

Hiermit erkläre ich, **Markus Wolfgang Robioneck**, an Eides statt, dass ich den wesentlichen Anteil an der Publikation:

Markus Wolfgang Robioneck, Miguel Pishnamaz, Nils Becker, Eftychios Bolierakis, Frank Hildebrand, Klemens Horst:

Development of early complications after treatment of trochanteric fractures with an intramedullary sliding hip screw in a geriatric population

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Die Anteile an der Arbeit waren wie folgt:

	Markus Wolfgang Robioneck	Frank Hildebrand	Miguel Pishnamaz	Nils Becker	Eftychios Bolierakis	Klemens Horst	Summe (%)
Studienüberwachung		30				70	100
Studiendesign/Konzeption	50	20				30	100
Datenerhebung	60		5	5		30	100
Datenauswertung	60		5		5	30	100
Statistische Auswert.	50					50	100
Bereitstellung von Materialien		20	20	10	10	40	100
Interpretation der Datenauswertung	60	20				20	100
Verfassung des Manuskripts	100						100
Korrektur des Manuskripts		30	10	5	5	50	100

Aus diesem wesentlichen Anteil ergibt sich selbstverständlich die Stellung als Erstautor

Markus Wolfgang Robioneck (Doktorand)

Als Doktorvater bestätige ich die Angaben von Markus Wolfgang Robioneck

Prof. Dr. med. **Klemens Horst**

Ich schließe mich der Erklärung von Prof. Dr. med. Klemens Horst als Koautor an

Univ.-Prof. Dr. med. Frank Hildebrand

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