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**Dislocation after primary unilateral total hip arthroplasty: hip geometry
and risk factors (a matched cohort analysis)**

Дислокација после уградње примарне унилатералне тоталне ендопротезе
кука: геометрија кука и фактори ризика (мечована кохортна студија)

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Dislocation after primary unilateral total hip arthroplasty: hip geometry and risk factors (a matched cohort analysis)

Дислокација после уградње примарне унилатералне тоталне ендопротезе кука: геометрија кука и фактори ризика (мечована кохортна студија)

SUMMARY

Introduction/Objective The purpose of this study was to determine if patient-related factors, such as length of stay in hospital, and preoperative usage of walking aids, and geometrical factors, measured with antero-posterior radiographs of hip, affect the risk of hip dislocation after total hip arthroplasty.

Methods A total of 36 of 433 (8.31%) patients with hip dislocation were identified in the institutional registry during the two years period. The data for patients with and without hip dislocation were matched and compared.

Results Hip dislocation more often occurred in patients who had used the walking aids before the operation compared to the ones who had not ($p < 0.001$). Also, the difference in the number of HD was noticed between the patients who stayed longer in the hospital after THA ($p < 0.001$) The patients with higher acetabular inclination angle ($p < 0.005$) and height of greater trochanter ($p < 0.001$) on radiographs had been more prone to hip dislocation. In addition to this, the "safe-zone" was not identified in our study ($p > 0.005$)

Conclusion Several factors, which influence hip dislocation, were identified in this study: patients characteristics and radiograph characteristics. Both groups of factors require attention and monitoring in future studies

Keywords: hip dislocation, biomechanics; complications-total hip arthroplasty; "safe zone"

САЖЕТАК

Увод/циљ Циљ истраживања је да утврди на који начин фактори као што су дужина постоперативне хоспитализације, употреба помагала за ходање пре операције као и геометријски фактори који су мерени на антеро-постериорном радиографском снимку, утичу на ризик од настанка дислокације кука након тоталне ендопротезе кука.

Метод Коришћењем институционалног регистра током двогодишњег периода идентификовано је 36 пацијената (8,31%) са дислокацијом кука, од укупно 433 пацијената са тоталном ендопротезом кука.

Резултати Добијени подаци пацијената са дислокацијом и без дислокације су упоређивани и анализирани. Дислокација кука била је чешћа код пацијената који су пре операције користили помагала за кретање, у односу на оне који нису ($p < 0.001$). Значајна разлика је регистрована код пацијената код којих је хоспитализација након операције трајала дуже ($p < 0.001$). Пацијенти са већим углом инклинације ацетабулума ($p < 0.005$) и вишим великим трохантером ($p < 0.001$) на радиографским снимцима су чешће имали дислокацију. Поред тога, „сигурна зона“ у нашој студији није идентификована.

Закључак У овом истраживању идентификовани су фактори који су у вези са дислокацијом кука као што су дужина постоперативне хоспитализације и употреба помагала за ходање пре операције. Такође, идентификовани су и радиографски фактори, који заслужују даљу пажњу и праћење у будућим истраживањима

Кључне речи дислокација кука; биомеханика; компликације-тотална артропластика кука; „сигурна зона“

INTRODUCTION

Total hip arthroplasty (THA) is an effective, common and costly operation [1]. It is considered the most successful procedure in orthopedic surgery since it relieves pain, increases mobility and quality of life, and provides a high level of patient survival [2]. Despite the efficacy of THA, hip dislocation (HD) represents a major problem after THA [2, 3]. The annual rate of HD after primary THA was reported to be 0.1-10% [3, 4] while revision due to HD dislocation was reported to represent 9–26% of all revisions of primary THAs [5].

Multiple factors have been suggested to contribute to HD [3, 6, 7]. Operation-specific risk factors include the hospital volume, surgeon's experience, surgical approach, suboptimal positioning of the acetabular and femoral component, soft-tissue imbalance, etc. [5, 7]. As the procedure-specific factors, acetabular cup diameter, femoral head diameter, femoral neck length, head-to-cup ratio, procedure type, and use of a liner were analyzed [8]. Although treatment outcome highly depends on the quality of surgical reconstruction of anatomical and biomechanical relations of the bone tissue [3], HD was noticed to occur even in the absence of procedure-specific mistakes. Thus, patient-specific risk factors for HD, including advanced age, high body mass index, comorbidities (especially psychiatric and neurologic diseases), low physical activity level, preoperative usage of walking aids (PUWA), impaired compliance (failure to comply to permitted activities after surgery), and absence of exercise therapy, were suggested as important [7, 9, 10, 11]. According to the most recent studies, the length of stay (LOS) after THA had been shortened [4, 7, 8]. Out of many different patient's and provider's characteristics that determine LOS [12], comorbidity is the most documented one [13]. It is also known that early mobilization results in the reduction of LOS and cost outcomes. [14].

Despite the number of researches done, the risk factors of HD are not yet fully understood [1, 15]. Recent studies examine the influence of factors such as alcohol consumption, some diseases, and postoperative activity restrictions, but also the existence of the safe zone for cup position in HD occurrence [6]. The main limitation of majority of published studies are following: small number of risk factors were analyzed, they failed to report data on functional abilities of patients before and after the surgery, did not provide a description of procedures used for physical rehabilitation, did not perform long-term follow up of patients, etc.

The main aim of our study was to assess the link between patient-related factors and hip geometry related to incidence of HD after THA.

METHODS

Patients

This clinical monocentric study was performed by prospectively gathering data on 433 patients that were subjected to THA between January 2016 and December 2017. Some patients were surgically operated due to nontraumatic indications, while others needed urgent surgery due to traumatic indications. Oral and written informed consent was obtained from all patients. The study was done in accordance with the Institutional Committee on Ethics.

By analyzing hospital records, we identified 36 patients who experienced HD after THA. HD was identified as an episode that required closed or open reduction of a THA prosthesis. In the case of multiple HD, only the first occurrence was evaluated. Since radiographs of two HD patients were not adequate for analysis (no visible lesser trochanter and iliac crest), those two HD patients were excluded from the analysis, which resulted in a total of 34 HD patients. Control group consisted of 34 patients, operated during the same period and under the same conditions, that did not experience HD after THA. Controls were matched to HD patients, using basic patients' characteristics: age in time of primary THA (± 3 years), gender, etiology responsible for THA (traumatology / nontraumatology), type of prosthesis (exactly), comorbidities (Charlson comorbidity score), and physical activity level before the operation. Exclusion criteria were evidence of infections, malignant disease, instability, THA revision, other major joint arthroplasty, or orthopedic surgery on the lower extremity 1 year before THA. Patients included in the study were followed for six months.

Surgical protocol

Patients were operated by 13 surgeons, 10 of them had 5-25 years of experience, and 3 of them less than 5 years of experience. All patients were operated according to the protocol of the Clinical Center, which requires the surgery to be done in general anesthesia and posterior approach, without reconstruction of the external rotators. Out of 433 patients, a total of 100 patients received cement type of prosthesis (patients older than 65); cement type prosthesis was received by 7 HD patients and 9 controls. Patients younger than 65 received noncement (total n=240, 17 HD patients, and 17 controls) and hybrid (total n=93, 10 HD patients, and 8 controls) type of prosthesis. The choice of prosthesis components and prosthesis size were at the discretion of the attending surgeon. Different designs (Implacast, DePuy, Zimmer, Stryker, Zimmer/Biomet) of cup/stem and femoral head sizes (28 or 32 mm) were used. The bearing surface for all prostheses was polyethylene on metal. In patients with a noncement and hybrid type of prosthesis head-on-polyethylene (PE) liner was used.

Postoperative protocol

During hospitalization, all patients had physical therapy according to standard protocol. Patients were verticalized immediately after the intervention, walked on crutches, with or without load bearing on the operated leg, depending on the type of THA and surgeon's opinion. Physiotherapy took place daily, except on weekends. General postoperative restrictions for the first three months were used.

Patient and implant characteristics

Baseline patients' data included age in the time of primary THA, gender, THA side, comorbidities, physical activity level, and etiology (diagnosis responsible for THA). We used

the Charlson index by defining the 19 comorbid conditions [16]. In addition to the Charlson score, individual comorbidities were included for separate analysis consisting of diabetes mellitus, rheumatoid arthritis, peripheral vascular disease, neurologic disease, pharmacologically treated psychiatric disease and consumption of more than 2 units of alcohol daily. Physical activity level, according to Devane, was quantified as the level from 0 to 5 [17].

Pre/postoperative data included analysis of mechanisms and time of dislocation, preoperative use of walking aids (PUWA), length of stay (LOS) in hospital after surgery and implementation of exercise therapy before and after THA. The patient was asked about any trauma or motions that led to the HD, if event represented the first or recurrent dislocation, how long ago the primary THA was performed, and whether he was subjected to physical and exercise therapy.

Operative notes were used to identify the operative side, surgeon, implant type, cup size, and femoral implant diameter.

Measurement of radiographic variables was performed using standard anteroposterior radiographs made immediately after THA. Measurement was performed by two independent authors, twice for each radiograph. The mean value of the four measurements was used for analysis. The reconstruction of the hip rotation center was performed by drawing a circle around the femoral head. Köhler line was drawn along the medial aspect of the ilium and ischium. First, a line through the base of the acetabular teardrop was drawn (Line 1). Then, a Köhler line was drawn: from the lateral border of the sciatic notch to the medial border of the obturator foramen. Finally, a line was drawn through the center of the femoral head to the iliac crest (Line 2). The acetabular teardrop was used, as a reference since it represents an accurate method to measure distances [12, 15]. The lateral lip of teardrop indicates the exterior acetabular wall. Cup position was assessed according to the acetabular abduction

angle (angle between the line 1 and 2), vertical offset and the horizontal offset. Vertical offset was measured from the center of the femoral head to the Line 1. Horizontal offset was measured from the center of the femoral head to the Köhler line (normal). The radiographic reconstruction of the abductor mechanism was measured using the height of the greater trochanter (HGT) as the distance between the Line 1 and the parallel line crossing the tip of the greater trochanter (Figure 1).

Statistics

The study data were analyzed by descriptive statistics and presented in tables. The mean value was used as a measure of central tendency and standard deviation as a measure of dispersion for continuous variables. The values of categorical variables were presented as rates or percentages. The normality of data distribution was tested by the Kolmogorov-Smirnov test. A chi-square test was used to assess the difference in the distribution of categorical data between the HD group and the control group. Student's T-test or Mann Whitney test was used to assess differences in mean values of interval data. Statistical analysis was performed in SPSS (version 20).

RESULTS

Out of 433 patients, 36 patients experienced HD, representing a rate of 8.31%. Thirty-three HD patients were stable after non-operative treatment, while 3 HD patients needed a revision. Out of 36 HD patients, two were excluded from the analysis, due to technical problems with radiographs.

HD patients and Control patients did not significantly differ regarding Age, Operated side, THA etiology, Charlson comorbidity score, neither were individual comorbidities more

frequent in HD patients. Also, physical activity levels were similar in HD and Control patients.

There was no statistically significant difference in the occurrence of HD after THA if the patient was operated by the surgeon with less or more experience ($p > 0.05$, Chi-squared test). There was a similar number of patients receiving pre/postoperative rehabilitation treatment in both groups, but PUWA was more frequently used in HD patients compared to control patients. HD patients also spent significantly more time in hospital after THA. Time of dislocation in HD group ranged from 3 to 3300 days after THA (median 282.50), and the most frequent mechanism was inappropriate movement. Late dislocations (>90 days after THA) were more frequent than the early ones.

HD patients and Control patients did not significantly differ in acetabular shell size, cup anteversion angle, the horizontal and vertical offset of a cup, nor the frequency of different femoral head sizes, cup position zone, and abductor mechanism zone. However, HD patients had significantly higher acetabular inclination angle and height of greater trochanter when compared to Control patients.

DISCUSSION

Hip dislocation remains the major complication after THA. While multiple reasons may be contributing factors leading to dislocation, precise identification of the exact reason is of major importance. As with any multifactorial problem, the prediction of postoperative outcomes is difficult. Results of our study have shown that LOS, PUWA and AI and HGT are associated with the occurrence of HD.

Understanding the factors associated with the occurrence of HD can help plan the operation, preventing the occurrence of HD [10, 18] and reducing treatment costs [3, 4, 19].

Since the Republic of Serbia does not have a national register of patients with THA, we used systematically collected data from our medical center.

In the most of the previous studies, it was shown that many factors are associated with the HD, but these studies investigated dominantly surgical factors, which were not in the focus of our research [18]. In our medical center, all surgeons use a posterior approach, the same type of prosthesis, and the same operating technique.

The main purpose of this study was to assess the patient-related factors and radiological factors on HD occurrence after THA.

HD is a significant problem in clinical practice [3, 4, 19]. Restoration of the native anatomy plays a crucial role in preventing instability [6]. Malposition of the acetabular component is associated with the occurrence of many complications, not only HD [20]. Some authors still accept some kind of "safe zone" for prosthesis placement [1, 4, 10] while others question whether it exists [6, 15].

Cup position with an inclination/abduction of $40\pm 10^\circ$ and an anteversion of 10 to 20° , so-called „safe zone" to avoid HD, is internationally considered desirable and used in clinical practice. Lewinnek defined the „safe zone“ after a study conducted on a small number of patients treated with only a postero-lateral approach. However, experience showed that components positioned in this zone can and do dislocate [4]. This was confirmed by HD occurrence even after the use of computer-assisted surgery during THA [20]. As mentioned before, some authors argue that „safe zone“ does not exist or that it is different for every single patient [6, 12]. Also, some authors claim that "safe zone" depends on the operative approach or some other factor [20].

Hip geometrical parameters have been suggested as important factors in the evaluation of the risk of HD [3, 4, 10, 19]. Our results show that patients who experienced HD had the higher acetabular inclination and lower height of greater trochanter. Previous studies shown

that the height of great trochanter depends on the soft tissue reparation and thigh muscle strength [1, 20]. Also, cup position was not significantly different between study groups which were aligned with findings of Esposito et al. [6]. This indicates that muscle strength is of great importance in the prevention of HD [14].

There is no consensus in literature data about optimal acetabular orientation since different referent systems, surgical techniques, and measurement techniques were used. The malposition of the acetabulum can lead to numerous complications among which is HD. This is explained by bigger bearing surface and instability [20].

The number of all observed HDs (n=34, 8.31%) in our study is on the upper limit described in the literature (0.3-10%) [1, 3, 4]. If we follow only operatively treated HDs (3 patients) frequency would be 0.69%. There are several factors such as the posterior operative approach, middle hospital volume, lack of surgeon experience, which could explain this high incidence of HD [4, 13]. Also, we included a wide range of patients in our study, even those patients with increased risk for HD: older patients with cement prosthesis, posttraumatic THA, psychiatric patients and patients with neuromuscular impairment. Older age is associated with a lack of coordination, senses and muscle weakness, comorbidity, bad compliance and preference to falling. Above mentioned characteristic of older patients increases the risk of HD.

Data that come from national registers or multicentric studies took patients with "ideal" characteristics such as: large femoral head, non-cement prosthesis, and numerous exclusion criteria [3, 19]. The advantage of our study was that we did not have a loss of patients because every single patient treated in our hospital was followed adequately as there is no other hospital where HD could be treated.

Another potential risk factor for HD is the so-called early mobilization regimen of physical therapy [21]. Every patient in our medical center is subsided to early mobilization, so we were not able to evaluate it as risk factor.

Surgeon experience and volume were not identified as significant factors for the occurrence of HD. All surgeons in our medical center had low patient volume.

Previous research showed that physiotherapy after THA enhances postoperative recovery [11, 21, 22] by promoting faster rehabilitation and improving functional outcomes. It is argued that even though intensity and frequency of ideal rehabilitation protocol are unknown, early multidisciplinary rehabilitation improves outcomes [11]. However, our results did not show that physiotherapy is a protective factor. The reason could be that physiotherapy is mandatory in our medical center for all patients after THA. Also, the number of patients included in our study could be insufficient to show the significance of physiotherapy.

The number of patients who suffered from HD is 14 in the first 90 days of surgery, and 20 patients after 90 days. Similar results were obtained in the study of Kunutsor et al. [3] where half of all HDs occurred in the first 3 months postoperatively.

LOS is an important component of the recovery and indicator of the overall cost after THA. Since the implementation of fast track surgery, there is a tendency to reduce the LOS in hospital to reduce costs, reduce number and seriousness of complications and increase number of free hospital beds [13]. Every hospitalization longer than 4 days [9] or 10 days [22] is considered a prolonged hospitalization. Shorter LOS is associated with better motivation and satisfaction of patients during recovery [9].

Some factors associated longer LOS are better documented (age, gender, comorbidity, economic status, PUWA) than other (volume of surgeon, infections, general anesthesia). High-quality studies should provide more evidence for the relationship between LOS and mentioned factors [21, 22].

Jørgensen et al. showed that longer LOS could increase the risk of complications but not the risk of HD [7]. On the other hand, shorter LOS doesn't mean more HDs [9] which is contradictory with findings of Maurehan et al. [23]. In our study, LOS was between 6 and 14 days, which is following other studies where a conventional surgical track regimen was used. Different treatment concept assumes a postoperative early mobilization program. Larger value of BMI is associated with longer LOS and increasing costs [24].

We showed that HD patients spent more time in hospital after THA and more frequently needed PUWA, which reflects their lower pre/post physical capabilities.

PUWA is associated with the occurrence of medical and non-medical complications [25]. PUWA is a sign of loss of hip muscle strength and in most cases is associated with older age and/or comorbidity [11]. Age over 70 years, female gender, depression, and BMI over 35 are highly associated with PUWA [22]. More research is needed to examine the impact of specific comorbidities on PUWA [25].

Results of our study showed that PUWA is a risk factor for HD which is aligned with the results of the study of Jørgensen et al. [25]. The impact of PUWA must be additionally confirmed in new studies.

There are several limitations to our study. The most significant one is that we investigate the three-dimensional problem by using two-dimensional X-ray images for measuring acetabular inclination. However, femoral anteversion were not measured. Also, we did not have an access to the software made for the use of measuring these parameters. All investigated parameters were measured manually. The number of patients included in our study is relatively small and the follow-up period is short, compared to other studies. Limitations of our study also include loss of some radiographic data, the lack of detailed registration of patient compliance to restrictions and missing clinical information included

loss of BMI data, absence of detailed functional results of the THA according to a clinical scale.

CONCLUSION

In conclusion, HD is a serious complication that may be attributed to the multiple factors. Having in mind results presented in this study, we suggest implementation of PUWA, LOS and hip geometry monitoring in addition to other well-known risk factors.

Conflict of interest: None declared.

Paper accepted

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Table 1. Basic patients' data

Parameter	HD patients	Control patients	<i>p</i>
Age (X ± SD)	66.05 ± 10.22	64.79 ± 9.85	<i>p</i> > 0.05 ^a
Gender (n)			
Male	10	10	<i>p</i> > 0.05 ^b
Female	24	24	
THA side (n)			
Left	13	16	<i>p</i> > 0.05 ^b
Right	21	18	
THA etiology			
Primary OA	17	20	<i>p</i> > 0.05 ^b
Congenital hip disorder	1	2	
Rheumatologic disorders	0	1	
Trauma	12	8	
Avascular necrosis	3	1	
Metabolic bone disorders	1	1	
Other	0	1	
Charlson comorbidity score			
0	1	3	<i>p</i> > 0.05 ^b
1	1	2	
2	4	6	
3	7	9	
4	7	7	
5	5	2	
6	3	3	
7	4	1	
8	2	1	
Individual comorbidities (n)			
Neurological diseases	2	1	<i>p</i> > 0.05 ^b
Diabetes mellitus	3	4	
Psychiatric diseases	6	1	
Vascular diseases	3	1	
Rheumatoid arthritis	0	2	
Alcohol consumption	1	0	
Physical activity level			
0	0	0	<i>p</i> > 0.05 ^b
1	0	0	
2	6	7	
3	16	13	
4	11	11	
5	1	3	

^aMann Whitney test; ^b χ^2 test

Table 2. Pre/post THA related data

Parameter	HD patients	Control patients	<i>p</i>
PUWA (n)			
Yes	19	4	<i>p</i> < 0.001 ^b
No	15	30	
LOS (days)	11.00 ± 2.71	8.82 ± 1.66	<i>p</i> < 0.001 ^a
Rehabilitation (n)			
Preoperative (Yes/No)	17/17	14/20	<i>p</i> > 0.05 ^b
Early postoperative (Yes/No)	34/0	34/0	
Post THA (Yes/No)	11/23	14/20	
HD mechanism			
Falls	5	/	<i>p</i> < 0.001 ^b
Inappropriate movement	11		
Sitting	3		
Bending	5		
Squatting	1		
Unknown	9		
Time of dislocation (n)			
Early/Late	14/20	/	<i>p</i> < 0.001 ^b

^aMann Whitney test; ^b χ^2 test

Table 3. Implant and radiographic data

Parameter	HD patients	Control patients	<i>p</i>
Acetabular shell size (mm)	51.08 ± 13.90	53.61 ± 3.77	<i>p</i> > 0.05 ^a
Femoral head size (mm)			<i>p</i> > 0.05 ^b
28 mm	18	13	
32 mm	16	21	
Acetabular inclination (degrees)	47.52 ± 6.07	45.18 ± 2.98	<i>p</i> < 0.05 ^c
Horizontal offset (mm)	31.00 ± 4.85	29.22 ± 3.07	<i>p</i> > 0.05 ^a
Vertical offset (mm)	22.50 ± 6.11	23.06 ± 5.69	<i>p</i> > 0.05 ^a
Height of greater trochanter (mm)	2.27 ± 2.88	0.46 ± 1.30	<i>p</i> < 0.01 ^a
Cup position			<i>p</i> > 0.05 ^b
Inside safe zone ^d	3	2	
Outside safe zone ^d	21	32	
Abductor mechanism			<i>p</i> > 0.05 ^b
Inside safe zone ^d	2	1	
Outside safe zone ^d	32	33	

^aMann Whitney test; ^b χ^2 test

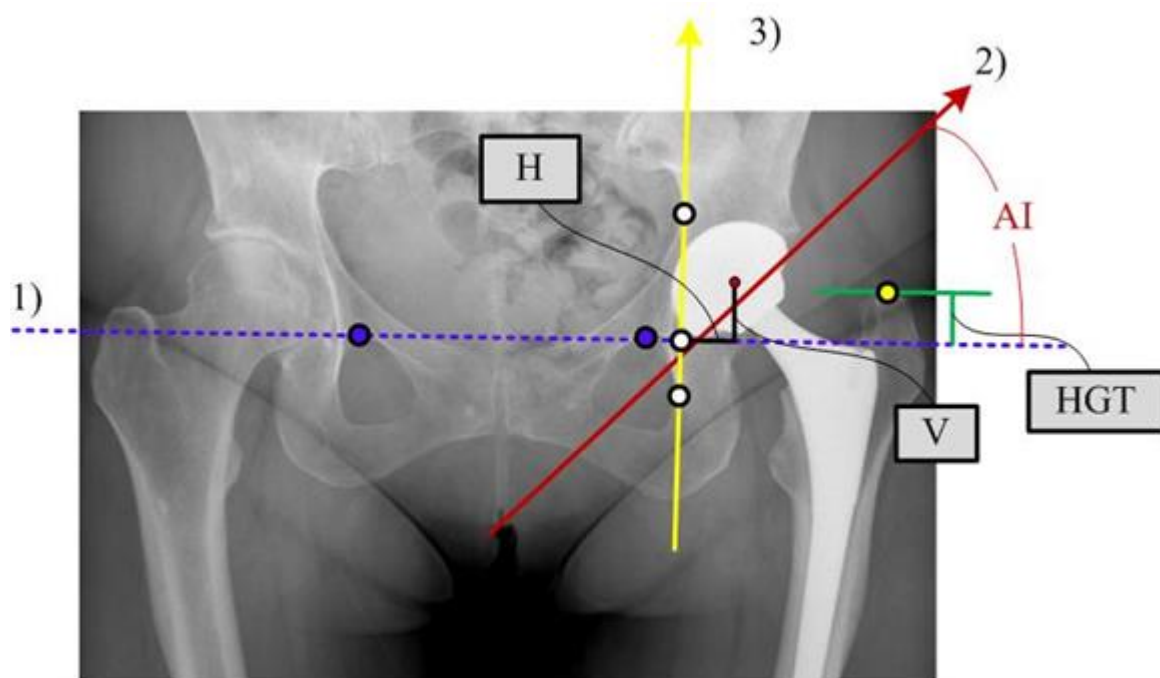


Figure 1. Representation of radiographic measurement parameters. Line 1—Horizontal; Line 2—For AI determination; Line 3—Köhler line; AI—Acetabular inclination; HGT—Height of greater trochanter; V—vertical offset; H—horizontal offset

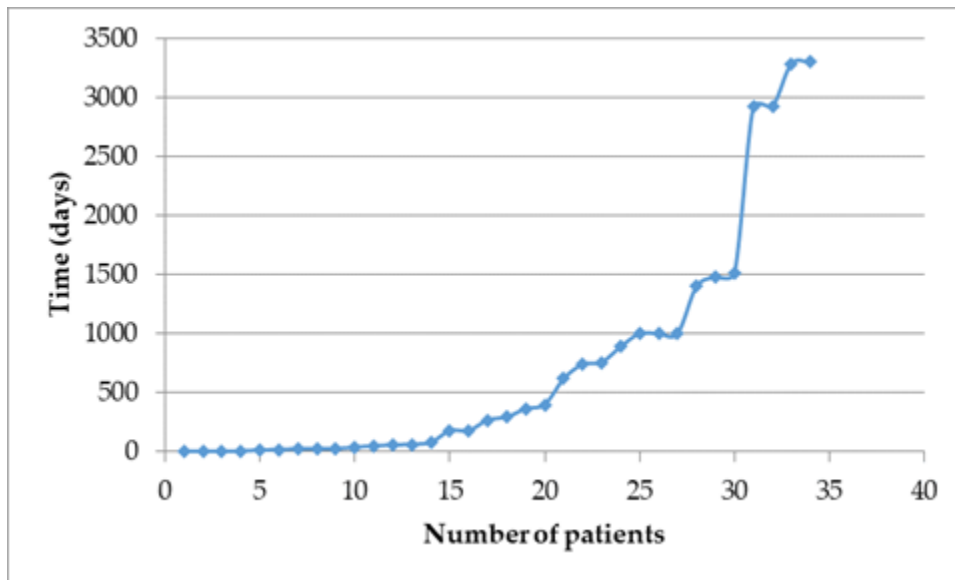


Figure 2. Time of occurrence of HD

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