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Experiences and results with a cementless femoral stem design: SL-PLUS MIA

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ABSTRACT

Aim: To evaluate the outcomes of the SL-PLUS® MIA cementless femoral stem (Smith & Nephew Orthopedics AG, Switzerland) application using the modified lateral approach.
Method: Demographic and clinical data, in addition to the operational outcomes of 42 patients who underwent total hip arthroplasty (THA) and partial hip arthroplasty (PHA) using the MIA cementless femoral stem with the modified lateral approach, between November 2015 and June 2017, were collected. Harris Hip Scores were calculated preoperatively and at 6 weeks, and 3 and 6 months, and 1 and 3 years postoperatively (a total of 6 times) in the THA group and at 6 weeks, and 3 and 6 months, and 1 and 3 years postoperatively (a total of 5 times) in the PHA group.
Results: Data from 24 THA patients with a diagnosis of primary or secondary coxarthrosis and 18 PHA patients with a diagnosis of isolated collum femoris fracture were collected. The average patient (26 females, 16 males, mean age 68.1 ± 13.1 years) follow-up period was 46.7 ± 1.4 months. There were no intraoperative or postoperative trochanteric fractures. No patients displayed the trendelenburg sign. The Harris Hip Scores of all of the patients increased postoperatively, proportional to the duration of follow-up.
Conclusions: In hip arthroplasties performed using the modified lateral approach, femoral preparation with a MIA femoral stem, which has a proximal lateral slope, reduced the tension in the trochanteric region. This was believed to lower the risk of trochanteric fractures. Additionally, this type of femoral component may help to avoid the trendelenburg sign postoperatively by protecting more gluteal muscle during the femoral preparation stage due to its proximal design.

Key words: Hip arthroplasty, femoral stem design, proximal femoral fracture, SL-MIA.

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Introduction

There is an increasing trend to utilize cementless femoral stems for total hip arthroplasty (THA) and partial hip arthroplasty (PHA) among orthopedic surgeons [1]. The reasons for this trend are lower incidences of aseptic loosening and risk of embolism and cardiopulmonary complications when compared to cemented stems in elderly patients [2,3]. However, cementless stems need to be placed press-fit in order to achieve rotational stability, which is related to the increasing risk of intraoperative proximal femoral fractures (mainly the greater trochanter) [4,5]. The risk of intraoperative proximal femoral fractures i.e. iatrogenic greater trochanter fracture caused by press-fit placement of cementless stems has been reported in the literature as between 3%–13% [6,7].

In addition to the press-fit technique, the selected surgical approach also affects the risk of intraoperative fractures. In the modified lateral approach, the greater trochanter is subjected to excessive pressure during the preparation of the femoral canal [8]. Thus, the design and geometrical features of femoral stems are important in order to obtain sufficient intraoperative stability without causing a fracture and ensure long-term survival postoperatively. The SL-PLUS™ MIA femoral stem (Smith & Nephew Orthopedics AG, Switzerland) is a modified version of the Zweymüller type SL-PLUS™ standard femoral stem (Smith & Nephew Orthopedics AG, Switzerland). The most prominent modification is the omission of the trochanteric wing, which spares the greater trochanter, provides better distribution of stress throughout the femur, and increases the rotational stability. Additionally, this femoral stem causes less harm to the gluteal muscles during the modified lateral approach [9].

The aim of this study was to report the demographic and clinical features with outcomes, and evaluate the advantages and the disadvantages of the stem during preparation and implantation in the modified lateral approach.

Materials and metods

A descriptive, retrospective study consisting of 42 patients, between 21–86 years of age, who underwent PHA or THA, between November 2015 and June 2017, and were followed up for at least 3 years following the surgery, was conducted here in. Written consent forms were signed by allof the patients. The ethics committee of Ufuk University was approved our study with the number of 2021-07-01.

Patients and documentation

Clinical and laboratory data were obtained including age, sex, anthropometric measurements, duration of symptoms (pain and walking disability), smoking status, alcohol consumption, indications for surgery, side of involvement, intraoperative blood loss, total length of hospital stay, intra- and postoperative complications, comorbidities, and treatments prior to the surgical procedure and management. Exclusion criteria included patient refusal, non-SL-plus MIA femoral implants such as M/L Taper® (Zimmer®, USA), Taperloc® (ZimmerBiomet®, USA), SL-PLUS® (Smith&Nephew, Switzerland) and Mathys® (Switzerland), Crowe class III–IV developmental dysplasia of the hip, lack of a 3 years postoperative follow-up, morbid obesity body mass index (BMI) of ≥35, and hip contractures.

Operation procedure

First-generation cephalosporins (2 g for >80 kg, 1 g for <80 kg) were administered to all of the patients intravenously 30 min before the operation. Spinal, combined spino-epidural, or

general anesthesia was utilized. All of the surgeries were performed by the same senior orthopedic surgeon using the direct modified lateral approach in the supine position. Following preparation and sterile draping, the bony landmarks of the hip were identified. Trochanter major was palpated and outlined. The incision was made 2-5 cm proximal of the tip of the trochanter major and extended parallel to the femur. An incision length of 10-13 cm was used for all patients was extended to the fascia. Hibs or rake retractors were utilized to expose the gluteus maximus fascia. The incision of the fascia was performed at the mid-trochanter level parallel to the femoral shaft. The proximal part of the gluteus maximus muscle was split along its fibers. The fascial sleeve and the gluteus maximus was retracted in order to expose the gluteus medius muscle. External rotation and flexion of the leg was used to facilitate dissection. The assistant on the opposite side of the table placed the leg in a "figure of 4" position (knee flexed and hip externally rotated). The flap was elevated from the bone until the hip joint was exposed. The labrum was incised at the proximal end of the flap in order to aid in dislocation of the femur. The femoral neck anteriorly and the femoral head was dislocated by traction while the leg was on external rotation. A standard femoral neck osteotomy was performed and the femoral head was removed from the field, thus exposing the acetabulum.

The cementless SL-PLUS™ MIA was used as the femoral stem, while the cementless EP-FIT™ press-fit acetabular cup system (both from Smith & Nephew Orthopaedics) was used in patients undergoing total hip arthroplasty (Figure 1). Intraoperative blood loss was also recorded.

Low molecular weight heparin was administered subcutaneously to all of the patients based on their calculated BMI at 6 h postoperatively. The total length of hospital stay, need for intensive care unit (ICU) stay, length of ICU stay, and transfusion requirements were recorded. All of the patients, including those with fractures, were mobilized during the first postoperative hours using a walker while bearing full weight, regardless of the indication day.

Preoperative (standing or supine), 48 h (supine), and 6 month (standing) postoperative radiographs of all of the patients were evaluated for the indication of operation, surgical outcome, and postoperative complications using the picture archiving and communications systems. Preoperative radiographs were reviewed by 2 independent orthopedic surgeons for the type of arthritis (primary, inflammatory, dysplasia, or avascular necrosis).

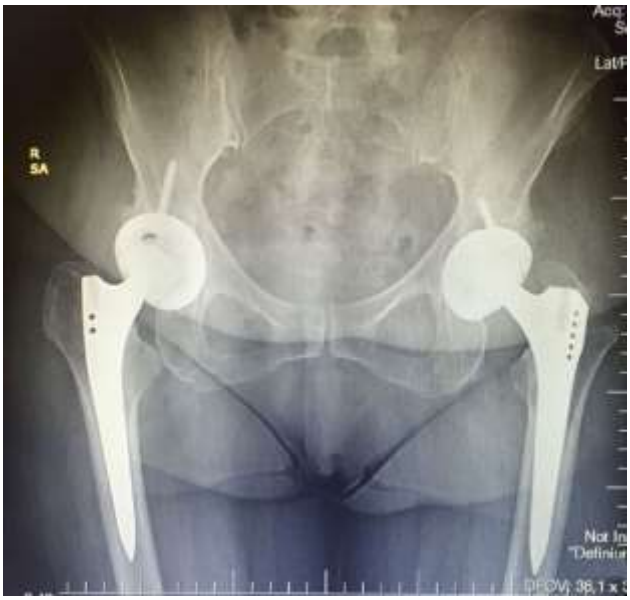

Figure 1. A 72-year-old female patient: Left primary hip arthroplasty was performed 2 years ago with the diagnosis of primary coxarthrosis. A SL-Plus femoral stem was used with the lateral approach. A fracture occurred in the trochanter major. Total hip arthroplasty was performed on the right side using a SL-MIA femoral stem with the lateral approach 1 year ago.

The Harris Hip Score (HHS)

The patients were evaluated preoperatively and postoperatively for functional status using

the Harris Hip Scale (HHS). The HHS was developed for the daily assessment of the results of hip surgery and is intended to evaluate various hip dysfunctions and their treatment methods in an adult population [10]. The HHS version validated for Turkish language was applied to our patients [11]. There are 10 questions in the survey and the scores ranged from 0 to 100, with higher scores representing better function and outcomes. The HHS was applied 5 times (6 weeks, and 3 and 6 months, and 1 and 3 years postoperatively) to the patients with PHA and 6 times (preoperatively, and 6 weeks, and 3 and 6 months, and 1 and 3 years postoperatively) to the patients with THA.

Statistical analysis

IBM SPSS Statistics 22 (IBM Corp, NY, USA) was used for statistical analyses. Descriptive analyses were given as minimum, maximum and "mean ± standard deviation (X+SD) for numerical data and number (n) and percentage (%) for non-numerical data.

Results

Of the 42 patients, 16 were males (% 38). The mean age of the patients was 68.1 ± 13.1 years (the youngest was 21 years old, while the oldest was 86 years old). Minimum follow-up 3.1 years of the patients with the mean of 46.7 ± 1.4 months. A 21-year-old female patient presented with a 5-year history of Sjögren's disease and underwent THA due to secondary osteoarthritis (Figures 2A and 2B). THA was performed on 24 patients (57.1 %), while PHA was performed on 18 patients (42.9 %), and 28 patients (66.7 %) had their right hip operated on.

The majority of the patients (73.8 %, n: 31) complained of pain for more than a year, while only the patients with a hip fracture were acutely symptomatic.

PHA was performed on 18 patients with a hip fracture who were significantly older than the average (79.2 ± 5.6 years) P: 0.041 (Figure 3). Moreover, these patients had comorbidities, such as type 2 diabetes mellitus (T2DM), chronic obstructive pulmonary disease (COPD), hypertension (HT), and congestive heart failure. The patient with Sjögren's disease, who was on long-term corticosteroid therapy, was the only patient with secondary osteoarthritis.

Half of the patients were smokers and only 3 patients in the THA group consumed alcohol, at a rate of less than once every 3 months. Osteoporosis, which was confirmed by laboratory and radiography, was present in 30.9 % (n:13) of the patients. Seven of the patients with osteoporosis were admitted with a hip fracture (53.8 %).

There were no intraoperative complications. Of the patients, 6 (14.2 %) were admitted to the ICU due to postoperative morbidities (COPD, HT) and were transferred to the ward after one night of stay. No blood transfusions were necessary postoperatively. Only 1 patient with T2DM had a wound infection, which was treated using intravenous antibiotics (second-generation cephalosporin).

Revision hip arthroplasty was performed on 1 patient due to a greater trochanter fracture following a fall after 1 year of primer surgery. There were no intraoperative or postoperative trochanteric fractures in any of the other patients in at least 3 years follow-up. The trendelenburg sign was not present in any of the patients. The demographic and clinical findings have been summarized in Table 1.

The HHS was not measured for patients who had preoperative hip fractures, but it was measured at 6 weeks, and 3 and 6 months, and 1 and 3 years postoperatively, and was found to be higher during the follow-up. The results are summarized in Table 2.

Table 1. Demographic and clinical findings of the groups (n: 32).

Parameters	**Values**
Mean age at surgery (years) (mean ± SD)	68.1 ± 13.1
Sex (M/F) (n)	11/21
Duration of symptoms (n, %)	
Acute	18 (42.8%)
1–3 years	14 (33.3%)
More than 3 years	10 (23.8%)
Indication for surgery (n, %)	
Primary osteoarthritis	23 (54.7%)
Secondary osteoarthritis	1 (2.4%)
Fracture	18 (42.8%)
Side of involvement (R/L) (n)	28/14
Type of surgery	
Total	24 (57.2%)
Partial	18 (42.8%)
Mean duration of hospitalization (days) (mean ± SD)	3.5 ± 1.2
Mean duration of ICU stay (days) (mean ± SD)	2.4 ± 1.1
Clinical data of patients (n, %)	
Smoking status (active)	16 (38%)
Obesity (BMI 25–35)	13 (30.9%)
Alcohol consumption	3 (7.1%)
Osteoporosis	10 (23.8%)
History of long-term corticosteroid use	1 (2.4%)
Comorbidities (n, %)	
T2DM	5 (11.9%)
COPD	1 (2.4 %)
CHD	2 (4.8%)
Sjögren's disease	1 (2.4%)
HT	11 (26.1%)
Intraoperative complications (n)	None
Duration of surgery (minutes) (mean ± SD)	
Total	54.6 ± 16.2
Partial	42.6 ± 9.7
Blood loss (mL) (mean ± SD)	370.4 ± 40
Postoperative complications (n)	1 (3.1%)
Wound infection	
Mean follow-up duration after surgery (months) (mean ± SD)	46.7 ± 1.4

ICU: intensive care unit, BMI: body mass index, T2DM: type 2 diabetes mellitus,
COPD: chronic obstructive pulmonary disease, CHD: coronary heart disease, HT: hypertension

Table 2. Mean Harris Hip Scale scores of the patients in the 2 subgroups.

Variables	Patients with fracture (PHA)	Primary and secondary OA patients (THA)
Pre-operatively	-	35.3 ± 8.8
Post-operatively 6th week	79.6 ± 3.1	81.2 ± 5.3
Post-operatively 3rd months	83.8 ± 5.2	84.8 ± 4.4
Post-operatively 6rd months	87.9 ± 5.4	90.7 ± 6.2
Post-operatively 1st year	88.7 ± 4.2	91.7 ± 3.4
Post-operatively 3rd years	90.4 ± 3.2	92.1 ± 3.5

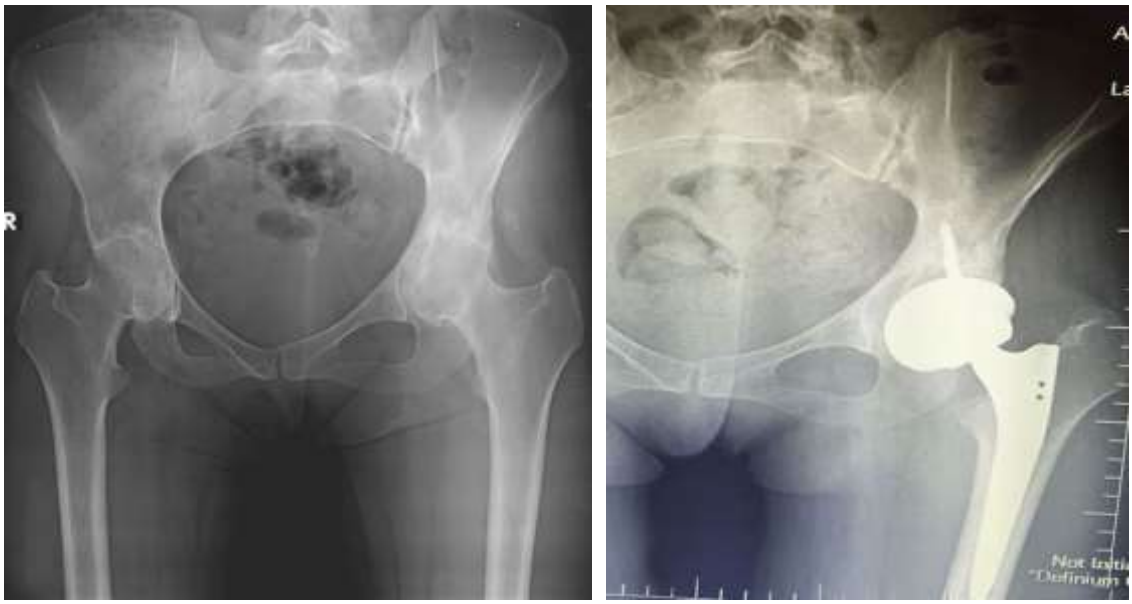

Figure 2. A) 21-year-old female patient with a history of Sjögren's disease: preoperative AP radiograph. **B)** A 21-year-old female patient with a history of Sjögren's disease total hip arthroplasty performed 2 years ago using SL-MIA.

Figure 3. A 73-year-old female patient: After a femoral neck fracture, partial hip arthroplasty was performed with a SL-MIA femoral stem (postoperative third month radiograph).

Discussion

Cementless press-fit femoral stems provide better osteointegration, owing to advanced technology, longer survival rates due to lower aseptic loosening rates, and enhanced safety because of lower cardiac complication risks caused by intraoperative cement complications, when compared to cemented stems. The surgeon utilization rates of these stems have been increasing for these reasons over the last 3 decades [12,13]. While there are various cementless femoral stem designs available, the SL-PLUS™ MIA version, which is a newer form of the rectangular cross-section femoral stem designed by Karl Zweymüller in 1979, was preferred herein [8,14,15].

This stem has a narrowed lateral shoulder that reduces the stress on the trochanteric area during femoral preparation, thus avoiding iatrogenic trochanteric fractures. Fractures of the proximal femur, which have been reported as between 3% and 13% during PHA or THA, negatively effects the surgical outcomes and quality of life [4–6,16]. The insertion of a cementless press-fit femoral stem and placement of the retractors for acetabular and femoral exposure during femoral and acetabular preparation are the cause intraoperative fractures of the proximal femur. Another reason is the lateral approach in the supine position [17,18].

These fractures require fixation in order to prevent the dislocation of the prosthesis and postoperative Trendelenburg sign [17]. The Trendelenburg sign was not observed in any of the THA or PHA patients postoperatively. Not only the surgical approach, but also the implant morphology and size, are important factors for the prevention of trochanteric injuries [17].

The fact that the MIA does not have a proximal shoulder like the Zweymüller facilitates the use of rectangular cross-section designs in both the lateral approach and anterior approach, which have recently gained popularity. Rectangular designs provide improved rotational stability when compared to other designs and allows early mobilization, especially in osteoporotic unstable hip fractures. Additionally, this design partially avoids complications like non-union and delayed mobilization, which can be caused by the osteosynthesis technique employed for unstable fractures seen in elderly patients. Moreover, these designs reduce the risk of trochanter major fracture in the anterior or lateral approach, where the exposure of the femur is difficult.

Shorter length of stay after arthroplasty operations is an important factor in lowering costs and ensuring a faster return to daily life. The mean length of hospital stay following THA or PHA has been reported as between 2.5 and 6 days in the literature [19]. Although no comparisons have been made in this study, the length of hospital stay was shorter in our study. Although total joint arthroplasties often require blood transfusions [20,21], none of the patients required transfusions in this study.

This is associated with the superiority of the surgical approach. It can also be indirectly associated with the type of prosthesis chosen due to ease of application. A superficial wound infection was observed in only 1 of the patients with T2DM, which was treated with antibiotherapy.

There are numerous studies in the literature focusing on the positive and negative effects of age, sex, obesity, osteoporosis, long-term corticosteroid use, and tobacco or alcohol consumption on arthroplasty outcomes [22,23]. In the current study, only 1 patient had a history of long-term (>6 months) oral corticosteroid use due to Sjögren's disease, 3 patients had a history of alcohol consumption, and 50% were active smokers. None of these patients differed from the others throughout the follow-up period. Patients with a BMI greater than 35 were excluded from the study; however, 13 patients with a BMI between 25 and 35 did not differ clinically either. The HHS was applied to the patients preoperatively and at 6 weeks, and 3 and 6 months, and 1 and 3 years postoperatively in the THA group, and at 6 weeks, and 3 and 6 months, and 1 and 3 years postoperatively in the PHA group in order to measure their functional status, and the scores had increased in both groups. This points to improved functionality as the healing process progresses and proves patient satisfaction and the success of the prosthesis.

Our study summaries the long-term follow up of the patients and the surgical outcomes of the SL-PLUS™ MIA stem.

Conclusions

The main limitations of the study are that different surgical approaches were not compared and a retrospective and descriptive study design. On the other hand, it is possible that the complication rates were low because all of the operations were performed by the same experienced surgeon. There is a paucity of data in the literature concerning the surgical outcomes of the SL-PLUS™ MIA stem. The SL-PLUS™ stem has been reported to be safe, even for the less experienced surgeons [24]. For these reasons, it could be argued that the SF-PLUS™ MIA stem, which is an update on the SL-PLUS™ stem, is easier to apply and has a better prognosis [24].

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Ethical statement: *The ethics committee of Ufuk University was approved this study with the number of 2021-07-01.*

Informed consent: *Informed consent was obtained from all individual participants included in the study.*

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References

[1] Mäkelä KT, Eskelinen A, Paavolainen P, et al. Cementless total hip arthroplasty for primary osteoarthritis in patients aged 55 years and older: Results of the 8 most common cementless designs compared to cemented reference implants in the Finnish Arthroplasty Register. Acta Orthop. 2010;81(1):42–52.

[2] Garland A, Gordon M, Garellick G, et al. Risk of early mortality after cemented compared with cementless total hip arthroplasty: a nationwide matched cohort study. Bone Jt J. 2017;99-B(1):37–43.

[3] Scanelli JA, Reiser GR, Sloboda JF, et al. Cemented Femoral Component Use in Hip Arthroplasty: J Am Acad Orthop Surg. 2019;27(4):119–27.

[4] [Andrew TA, Flanagan JP, Gerundini M, et al. The isoelastic, noncemented total hip arthroplasty. Preliminary experience with 400 cases. Clin Orthop. 1986;(206):127–38.

[5] Falez F, Santori N, Panegrossi G. Intraoperative type 1 proximal femoral fractures. J Arthroplasty. 1998;13(6):653–9.

[6] [Fitzgerald RH, Brindley GW, Kavanagh BF. The uncemented total hip arthroplasty. Intraoperative femoral fractures. Clin Orthop. 1988;(235):61–6.

[7] [Moroni A, Faldini C, Piras F, et al. Risk factors for intraoperative femoral fractures during total hip replacement. Ann Chir Gynaecol. 2000;89(2):113–8.

[8] [Hendel D, Yasin M, Garti A, et al. Fracture of the greater trochanter during hip replacement. Acta Orthop Scand. 2002;73(3):295–7.

[9] [Ike Hiroyuki, Inaba Yutaka, Kobayashi Naomi, T et al. bone remodelling after total hip arthroplasty with sl plus stem and SL PLUS MIA stem. Orthopaedic Proceedings 2016 98-B:Supp_2, 60-60

[10] Nilsdotter A, Bremander A. Measures of hip function and symptoms: Harris Hip Score (HHS), Hip Disability and Osteoarthritis Outcome Score (HOOS), Oxford Hip Score (OHS), Lequesne Index of Severity for Osteoarthritis of the Hip (LISOH), and American Academy of Orthopedic Surgeons (A. Arthritis Care Res. 2011;63(S11):S200–7.

[11] Çelik D, Can C, Aslan Y, et al. Translation, cross-cultural adaptation, and validation of the Turkish version of the Harris Hip Score. HIP Int. 2014;24(5):473–9.

[12] Veldman HD, Heyligers IC, Grimm B, et al.Cemented *versus* cementless hemiarthroplasty for a displaced fracture of the femoral neck: a systematic review and meta-analysis of current generation hip stems. Bone Jt J. 2017;99-B(4):421–31.

[13] [13] Apostu D, Lucaciu O, Berce C, et al. Current methods of preventing aseptic loosening and improving osseointegration of titanium implants in cementless total hip arthroplasty: a review. J Int Med Res. 2018 Jun;46(6):2104–19.

[14] Zweymüller K. A cementless titanium hip endoprosthesis system based on press-fit fixation: basic research and clinical results. Instr Course Lect. 1986;35:203–25.

[15] Affatato S, Comitini S, Fosco M, et al. Radiological identification of Zweymüller-type femoral stem prosthesis in revision cases. Int Orthop. 2016;40(11):2261–9.

[16] Fernandez-Fernandez R, García-Elias E, Gil-Garay E. Peroperative fractures in uncemented total hip arthrography: results with a single design of stem implant. Int Orthop. 2008;32(3):307–13.

[17] Miettinen SSA, Mäkinen TJ, Kostensalo I, et al. Risk factors for intraoperative calcar fracture in cementless total hip arthroplasty. Acta Orthop. 2016 3;87(2):113–9.

[18] Lindahl H. Epidemiology of periprosthetic femur fracture around a total hip arthroplasty. Injury. 2007;38(6):651–4.

[19] [19] Antoniou J, Martineau PA, Filion KB, et al. In-Hospital Cost of Total Hip Arthroplasty in Canada and the United States: J Bone Jt Surg-Am Vol. 2004 Nov;86(11):2435–9.

[20] Moonen AFCM, Thomassen BJW, Knoors NT, et al. Pre-operative injections of epoetin-α *versus* post-operative retransfusion of autologous shed blood in total hip and knee replacement: A Prospective Randomised Clinical Trial. J Bone Joint Surg Br. 2008;90-B(8):1079–83.

[21] Pola E, Papaleo P, Santoliquido A, et al. Clinical Factors Associated with an Increased Risk of Perioperative Blood Transfusion in Nonanemic Patients Undergoing Total Hip Arthroplasty: J Bone Jt Surg-Am Vol. 2004;86(1):57–61.

[22] Karlson EW, Mandl LA, Aweh GN, et al. Total hip replacement due to osteoarthritis: the importance of age, obesity, and other modifiable risk factors. Am J Med. 2003;114(2):93–8.

[23] Boddapati V, Fu MC, Su EP, et al. Preoperative Corticosteroid Use for Medical Conditions is Associated with Increased Postoperative Infectious Complications and Readmissions After Total Hip Arthroplasty: A Propensity-Matched Study. Am J Orthop Belle Mead NJ. 2018;47(12).

[24] Labek G, Kovac S, Levasic V, et al. The outcome of the cementless tapered SL-Plus stem: an analysis of arthroplasty register data. Int Orthop. 2012;36(6):1149–54.