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세라믹-금속 베어링의 인공 고관절 전치환술에서 다리길이 변화가 금속이온 방출에 미치는 효과

제주대학교 대학원

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세라믹-금속 베어링의 인공 고관절 전치환술에서 다리길이 변화가 금속이온 방출에 미치는 효과

지도교수 서규범

노영호

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심사위원장 최성욱

위 원 서규범

위 원 박용근

제주대학교 대학원

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The Effect of Leg length change and Metal ion release following Ceramic-on-Metal Total hip arthroplasty

Young-Ho Roh

(Supervised by professor Kyu-Bum Seo)

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Thesis director, Kyu-Bum Seo, Prof. of Orthopedic Surgery

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Department of Medicine

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JEJU NATIONAL UNIVERSITY

ABSTRACT

Introduction: The ceramic-on-metal (CoM) bearing has the theoretical advantages over ceramic-on-ceramic (CoC) and metal-on-metal (MoM) bearings. The advantages include lower risks of squeaking, fracture and metal ion production compared to MoM coupling. The objective of this study was to analyze factors that affect the metal ion release of the CoM bearing and to compare clinical performance with CoC bearings.

Methods: We enrolled 173 total hip arthroplasty (THA) cases of 146 patients into 2 groups. Group 1 (CoM group) had 114 cases of THA in 96 patients, while Group 2 (CoC group) had 59 cases in 51 patients. In addition, within the group 1, 48 patients and 30 patients were sub-categorized into group 1-A with leg length change (LLC) less than 1 cm and into group 1-B with LLC greater than 1 cm. The level of serum metal ions was measured before operation and postoperative 3 months, 6 months, 1 year and annually thereafter. Functional scores and plain radiographs were obtained for the analysis.

Results: The level of cobalt (Co) 2 years after surgery and the level of chromium (Cr) 1 year after surgery showed significantly higher in the group 1 than the group 2 (Co: $P < 0.041$; Cr: $P < 0.001$). LLC indicated statistically significant positive correlation between serum metal ion levels (Co: $r = 0.211$, $p = 0.046$; Cr: $r = 0.281$, $P = 0.007$) among CoM bearing THAs. In comparison of the average metal ions level changes, group 1-B showed higher level of Co ion ($P = 0.055$) and of Cr ion ($P = 0.025$) than group 1-A.

Conclusion: Patients who underwent with CoM bearing THAs with large LLC are at higher risks of complications associated with metal ions. Thus, in these patients, long-term follow-up measures are necessary for detection of serum metal ion levels.

초록

서론: 세라믹-금속 (CoM) 베어링은 세라믹-세라믹 (CoC) 및 금속-금속 (MoM) 베어링에 비해 이론적인 이점이 있다. CoC 베어링에 비해서는 삐걱거리는 소리와 파손이 적으며, MoM 베어링에 비해서는 금속 이온 배출의 위험이 낮다. 이 연구의 목적은 CoM 베어링에서 금속 이온 배출에 영향을 미치는 요인을 분석하고 CoC 베어링과의 임상 결과를 비교하고자 한다.

방법: 146 명의 환자를 대상으로한 총 173 례의 인공 고관절 전치환술 (THA)을 2 개의 그룹으로 구분하였다. 그룹 1 (CoM 베어링)에서는 96 명의 환자에서 114 례의 THA 가 시행되었으며 그룹 2 (CoC 베어링)에서는 51 명의 환자에서 59 례의 THA 을 시행하였다. 또한 그룹 1 은 다시 수술 전후의 다리 길이 변화 (LLC)를 기준으로 하여 1cm 미만인 48 명의 환자를 그룹 1-A 로 LLC 가 1cm 이상인 30 명의 환자를 그룹 1-B 로 세분화하였다. 수술 전과 수술 후 3 개월, 6 개월, 1 년 및 그 이후로는 매년 혈중 금속 이온 수준을 측정했다. 그 외에 다른 분석을 위해 임상지표를 측정하고 일반 방사선 사진을 촬영하였다.

결과: 수술 2 년 후 혈중 코발트 (Co) 농도와 수술 1 년 후 혈중 크롬 (Cr) 농도는 그룹 2 보다 그룹 1 에서 유의하게 높았다 (Co: $p < 0.041$, Cr: $p < 0.001$).

LLC는 CoM 베어링으로 시행한 THA 그룹에서 혈중 금속 이온 수준 (Co: r = 0.211, p = 0.046; Cr: r = 0.281, P = 0.007) 과 통계적으로 유의한 양의 상관 관계를 나타내었다. 그룹 1-B 에서 그룹 1-A 보다 평균 혈중 금속 이온 수준의 변화가 더 높게 나타났다 (Co: $p = 0.055$, Cr: $p = 0.025$).

결론: CoM 베어링으로 THA 를 시행한 환자에서 LLC 가 큰 경우에는 금속 이온과 관련된 합병증의 위험이 더 높다. 따라서 이러한 환자의 경우 혈중 금속 이온 수준을 감지하기 위해 장기적인 추적관찰이 필요하다.

I. Introduction

As total hip arthroplasty (THA) increases in young, healthy and active patients, the demand for hard-on-hard bearing surface is also increasing (1, 2). In order to improve a long-term survival of THA, hard-on-hard bearings, such as ceramic-on-ceramic (CoC) and metal-on-metal (MoM), are often used. Despite its lower rate of wear and osteolysis, ceramic breakage due to brittleness of CoC bearing has been often reported (3). Several studies have reported that CoC bearing produce 0.004% head fracture and 0.22% liner fracture (4-6). On the other hand, main concerns for MoM bearings are metal ion release such, as cobalt (Co) and chromium (Cr), and their potential interactions with immune system leading to local reactions, such as pseudotumor and aseptic lymphocyte dominated vasculitis as well as systemic adverse effects on cardiovascular, nervous and endocrine systems due to massive wear (7-9).

To minimize the complexity associated with CoC and MoM bearings, there are new option such as ceramic-on-metal (CoM) bearings that combine ceramic femoral heads and metal alloy liners by mixing a variety of hard bearing surfaces (10, 11). The theoretical advantages of this combination is that the risk of component breakage is lower compared to CoC bearings, and wear and metal debris production is reduced compared to MoM bearings, and can be considered even in patients with high physical activity.

In several studies of in vitro hip simulators have been conducted to investigate the wear rate of CoM bearings. Affatato et al. (12) and Reinders et al. (13) reported that significantly greater wear in CoM bearings compared with CoC bearings. Despite benefits of in vitro study in understanding wear behaviors of each THA design, only few studies investigated the in vivo performance of CoM bearings by comparing serum metal ion levels and quantitative clinical scores between CoM and MoM bearings.

Hence, the aim of this study was to analyze factors that affect the metal ion release of the CoM bearing and to compare clinical performance with CoC bearings using validated functional outcome scores and complications.

II. Materials and Methods

1. Patients

A total of 173 primary THAs and 147 patients were enrolled into the study. THA was performed using 114 CoM bearings in 96 patients and 59 CoC bearings in 51 patients. All these surgeries were performed by 1 skilled orthopedic surgeon in a single institution in the same manner. In the group 1 (CoM group), 18 patients underwent bilateral THAs, while the remaining 78 patients underwent unilateral THAs. In the group 2 (CoC group), 8 patients and 43 patients underwent bilateral and unilateral THAs, respectively. Vincent et al(14). reported that less than 1cm of postoperative leg length discrepancy is acceptable in THA. Among the unilateral CoM THA group, the 2 groups were divided based on leg length change (LLC) before and after surgery. 48 patients with LLC increased by less than 1cm were classified into group 1-A, and 30 patients with LLC increased by more than 1cm were classified into group 1-B. All patients undergoing THA between March 2010 and December 2015 with at least 3 years of follow-up period were considered for inclusion into the study.

The inclusion criteria were as follows: (1) patients aged over 20 years; (2) patients with primary and secondary osteoarthritis, hip degeneration after previous septic arthritis, femur neck fracture and osteonecrosis of femur hhead.

The exclusion criteria were as follows: (1) women of child bearing chance; (2) history of prior THA or hip fusion (3) inflammatory joint disease; (4) renal function impairment (glomerular filtration rate <30 ml/min); (5) metabolic bone diseases except osteoporosis; (6) patients with an incomplete past medical history and physical examinations. Serum metal ion levels, clinical functional outcomes, and surgical parameters were evaluated in all patients. The patient sex, age, body mass index (BMI), follow-up periods and preoperative diagnoses were investigated as demographic factors.

2. Surgical Technique and implant

All patients received identical devices in each group except only for acetabular liner (metal or ceramic). Pinnacle acetabular shell consist of Titanium-6Aluminium-4Vanadium alloy (Pinnacle; DePuy®, Warsaw, IN, USA), Biolox delta femoral head consist of Zirconia toughened Alumina composite and cementless collarless femoral stem consist of Titanium-6Aluminium-4Vanadium alloy (Summit; DePuy®, Warsaw, IN, USA) were used in all of the patients. The group 1 used the Cobalt-Chromium-Molybdenum alloy (Ultamet; DePuy®, Warsaw, IN, USA) as the acetabular metal liner and group 2 used Biolox delta liners consisting of Zirconia-Alumina as a ceramic liner.

All surgeries were performed by one orthopedic surgeon (NGW) and the surgical technique used in the operation was the same in all patients with posterior approach. Standard postoperative care and rehabilitation was performed in the same way for all THA patients. Patients were followed up at an outpatient clinic at 1 month, 3 months, 6 months, 1 year and annually after surgery.

3. Metal ion level measurements

Blood samples for metal ion analysis were taken from all patients 3 months, 6 months, 1 year after surgery and annually thereafter. Samples were obtained using a stainless steel hypodermic needle attached to a plastic collection tube. The serum Co and Cr levels were measured using a plasma mass absorption spectrometry (Spectr AA-800H, Varian Inc., Palo Alto, California, USA). The limits of detection Co and Cr were 0.05μg/L and 0.1μg/L, respectively. The toxic cut-off levels for Co and Cr were 7.00 μg/L and 7.00 μg/L or above, respectively (15, 16). In CoC bearings, Co and Cr ion measurement was measured for a quality control. The Co and Cr change (ΔCo and ΔCr) was the calculation of the difference between levels of serum Co and Cr just before and 3 years after surgery. Any changes in serum ion levels were marked + for an increase and – for a decrease. All laboratory analyzes were performed according to the protocol and no personal information was displayed.

4. Clinical outcome measurements

All patients were evaluated for clinical outcomes using the Harris Hip Score (HHS) (17) and Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) (18) preoperatively and at 3 months, 6 months, 1 year and annually after the operation. To identify the squeaking, we performed physical examination and history taking about friction sound during the outpatient clinic visit (19). The research nurse completed the questionnaire directly to the patients who visited outpatient clinic by a blind protocol.

5. Radiologic outcome measurements

Radiological assessment was undertaken on preoperatively, immediately postoperatively, at 6 weeks, 3 months, 6 months, 1 year postoperatively and annually follow-up. Acetabular component inclination was measuring the angle between a horizontal inter-ischial line and a longest line of an ellipse representing an acetabular component on a standing radiograph of the entire lower extremity. Acetabular component anteversion was measured as the angle between the line touching the opening surface of the acetabular component and a line perpendicularly drawn to the table on a translateral radiographs (20). Assessment on postoperative radiographic measurements of leg length as defined by Paley et al. (21) used standing radiographs of the entire lower extremity. The images were taken at the point when patients were stand on full weight bearing after the operation. Any LLCs were marked + for an increase and – for a decrease. Radiographic evaluation was performed by a single radiologist (CYH). For intraobserver reliability, the average of the values measured 3 times for each patient was used.

6. Statistics

The Clinical characteristics and surgical factors for continuous variables between the group 1 and 2 were analyzed using the Student t-test and Mann-Whitney test. In contrast, the Chi-square test and Fisher's exact test were used for categorical variable analysis. Pearson's correlation analysis method was used to determine the relationship between blood metal ion level and patient-related factors, surgical factors, clinical scores and location of acetabular component positions. A linear mixing model was used because there was an omission value of the measured serum metal ion level as a method to identify the change in blood metal ion levels repeated after surgery. Statistical analysis was performed using the SPSS Statistics version20.0 (IBM Corp., Armonk, NY). Statistical significance was defined as a p value < 0.05.

III. Results

A total of 173 cases and 147 patients were analyzed. There were 59 male and 88 female patients with the mean age of 61.4±14.6 years. The mean of the follow-up period was 6.99 ±1.36 years. The preoperative diagnosis was avascular necrosis of the femoral head in 88 cases (49.1%), proximal femoral fractures in 49 cases (29.3%), primary osteoarthritis in 24 cases (14.4%), secondary osteoarthritis in 9 cases (5.4%) and previous septic arthritis in 3 cases (1.8%). Group 1 had 114 cases, including 96 patients, and group 2 had 59 cases, including 51 patients. No differences were observed with gender (P = 0.243), age (P = 0.756), BMI (P = 0.588) and follow-up periods (P = 0.142) between the group 1 and 2 (Table 1).

Although the surgical characteristics of each group were similar, the mean operation time was longer (P = 0.047) in the group 2. No differences were observed with LLC (P = 0.348), acetabular cup inclination (P = 0.101), acetabular cup anteversion (P = 0.755), cup size (P = 0.270), head size (P = 0.113) and intra-operative bleeding (P = 0.760) between group 1 and 2 (Table 1).

Table 1. Demographic and surgical characteristics of the patients for each group.

Characteristic	**Group 1 (CoM; N=96)**	**Group 2 (CoC; N=51)**	**P value**
Gender {Patients (hips)}			0.243
Male	41 (50)	18 (22)	

Female	55 (64)	33 (37)	
Age			
Mean (range)	61.0 (25-90)	61.8 (35-85)	0.756
BMI			
Mean (range)	24.3 (15.8-39.1)	24.7 (17.7-49.0)	0.588
Diagnosis {Patients (hips)}			
AVN	44 (57)	24 (31)	
Primary OA	13 (16)	8 (8)	
Secondary OA	5 (5)	3 (4)	
Trauma	33 (35)	14 (14)	
Previous septic arthritis	1 (1)	2 (2)	
Follow-up (years)			
Mean (range)	5.1 (3.7-7.0)	4.7 (3.4-7.1)	0.142
LLC (mm)			
Mean (range)	6.1 (-1.1-23.3)	5.3 (-1.3-17.1)	0.348
Acetabular cup			
inclination	41.0 (25.9-55.0)	42.3 (25.7-.54.4)	0.101
Mean (range)			
Acetabular cup	23.3 (8.2-38.7)	23.6 (6.2-35.2)	0.755
anteversion			
Mean (range)	50.5 (44-60)	49.3 (44-56)	0.270
Cup size			
Mean (range)	34.5 (28-36)	33.5 (28-36)	0.113
Head size			
Mean (range)	91.0(61-229)	105.6 (74-259)	**0.047**

Operation time (minute)			
Mean (range)	864.7 (150-4500)	836.6 (150-2500)	0.760
IntraOP Bleeding (ml)			
Mean (range)			

CoM, ceramic-on-metal; CoC, ceramic-on-ceramic; BMI, body mass index; AVN, avascular necrosis of the femoral head; OA, osteoarthritis; LLC, leg length change; Postop, postoperative; IntraOP, intraoperative

When Co and Cr serum ion levels were continually examined over time, there was no significant difference between the 2 subgroups until postoperative 1 year for Co and postoperative 6 months for Cr. However, since then, there have been statistically significant changes in serum Co and Cr levels between the 2 groups. In the group 1, serum cobalt ion level measured at 2 years ($P = 0.041$) and 3 years ($P = 0.026$) after surgery were higher than in the group 2. In the group 1, serum chromium ion levels measured at 1 year after surgery ($P < 0.000$), 2 years ($P < 0.000$), and 3 years ($P = 0.001$) were higher than in the group 2. It is shown in Table 2 that the serum metal ion level is plotted according to the time of examination. The linear mixed model was used to analyze the interaction between time and the serum metal ion level repeatedly measured in the group 1 and 2. The results were statistically significant at both the Co ($P = 0.017$) and Cr ($P < 0.000$) serum ion levels.

Clinical outcomes of group 1 and 2 were analyzed based on the results of the most recent examination. No statistical differences in pain ($P = 0.131$), stiffness ($P = 0.065$), function ($P = 0.054$) and total WOMAC scores ($P = 0.083$). Similarly, no significant differences were seen between the 2 groups in HHS ($p = 0.159$) (Table 2). The squeaking incidence were observed in 15 cases in the group 1 (15.6%) and in 6 cases in the group 2 (11.1%). There was no statistically significant difference in friction incidence between group 1 and 2. ($P = 0.358$).

Table 2. Comparison of Serum ion levels at each time point and functional scores between the 2 subgroups.

Group		Group 1 (CoM; N=96)	Group 2 (CoC; N=51)	P value
	Time point			
Metal ion(μg /L)				
Cobalt (range)	pre	0.22±0.32 (0.00-1.20)	0.14±0.45 (0.00-1.60)	0.874
	3 months	0.56±0.97 (0.00-4.20)	0.32±0.78 (0.00-2.10)	0.230
	6 months	0.47±1.05 (0.05-5.50)	0.50±1.19 (0.00-3.60)	0.920
	1 year	0.59±1.43 (0.05-6.90)	0.30±0.50 (0.05-2.10)	0.213
	2 year	1.38±2.56 (0.65-9.70)	0.24±0.70 (0.05-2.90)	**0.041**
	3 year	1.49±1.59 (0.90-12.80)	0.29±0.81 (0.00-2.10)	**0.026**
Chromium (range)	pre	0.27±0.13 (0.00-0.82)	0.25±0.19 (0.00-0.63)	0.792
	3 months	0.43±0.40 (0.00-1.80)	0.31±0.38 (0.00-1.81)	0.352
	6 months	0.67±0.90 (0.10-6.20)	0.37±0.53 (0.10-2.70)	0.096
	1 year	1.47±1.47 (0.10-6.50)	0.41±0.30 (0.10-1.98)	**0.000**
	2 year	2.02±2.09 (0.10-8.40)	0.28±0.22 (0.10-1.90)	**0.000**
	3 year	1.76±1.92 (0.10-8.80)	0.26±0.21 (0.10-1.45)	**0.001**
WOMAC				
Pain (0-20)		2.63±3.43	1.13±2.72	0.131
Stiffness (0-8)		0.82±1.37	0.74±0.74	0.065
Function (0-68)		12.89±13.70	11.85±9.53	0.054
Total (0-96)		16.34±17.49	10.45±11.35	0.083
HHS (0-100)		83.80±9.85 (61-96)	87.76±7.06 (72-96)	0.159

Values are expressed as mean ± standard deviation (range, μg/L in metal ion);CoM, ceramic-on-metal; CoC, ceramic-on-ceramic; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; HHS, Harris Hip Score

Correlations among last follow-up serum metal ion level, patient related factors, surgical characteristics, acetabular component positions and clinical outcomes were assessed in CoM THA patients. There were statistically significant positive correlations between serum Co levels and LLC (r = 0.211, p = 0.046) as well as between the serum Cr levels and LLC (r = 0.281, P = 0.007). In addition, surgical characteristics, acetabular cup position, head and cup size did not show any correlations with the metal ion level (Table 3). In comparison of average changes in metal ion levels, group 1-B (0.25 ± 0.77 μg /L) showed more increases than group 1-A (0.13 ± 0.31 μg /L) in Co ion, but it did not have statistical significance (P = 0.055). Also, group 1-B (0.68 ± 0.77 μg /L) showed higher increases in Cr ion level changes than group 1-A (0.34 ± 0.34 μg /L) with statistical significance (P = 0.025) (Table 3).

Table 3. Correlation between each variable and serum metal ion levels in the patients with CoM group. Comparison of serum metal ion levels change in unilateral CoM group, according to the difference LLC after surgery.

CoM group Factor	**Cobalt**	**P value**	**Chromium**	**P value**

Age	r = -0.056	0.602	r = 0.034	0.753
BMI	r = 0.075	0.481	r = 0.079	0.458
Op. time	r = -0.002	0.984	r = 0.047	0.659
Op. Bleeding	r = -0.021	0.843	r = -0.025	0.816
AI	r = 0.189	0.074	r = 0.126	0.236
AA	r = 0.172	0.070	r = 0.182	0.074
LLC	r = 0.211	**0.046**	r = 0.281	**0.007**
Head size	r = 0.107	0.316	r = 0.096	0.367
Cup size	r = -0.030	0.777	r = 0.041	0.698
HHS	r = 0.135	0.405	r = 0.117	0.471
Pain	r = 0.019	0.868	r = 0.110	0.342
Stiffness	r = 0.004	0.971	r = 0.104	0.370
Function	r = -0.009	0.937	r = 0.028	0.811
Total WOMAC	r = -0.003	0.979	r = 0.052	0.657

	CoM group (N = 78)		**P value**
Metal ion (μg /L)	**Group 1-A**(N =48)	**Group 1-B**(N=30)	
ΔCo	0.13 ± 0.31	0.25 ± 0.77	0.055
ΔCr	0.34 ± 0.34	0.68 ± 0.76	**0.025**

r, Pearson's coefficient of correlation; BMI, body mass index; Op, operation; ACI, acetabular cup inclination; ACA, acetabular cup anteversion; LLC, leg length change; HHS, Harris Hip Score; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; CoM, ceramic-on-metal; Group 1-A, LLC < +1cm; Group 1-B, LLC ≥ +1 cm; ΔCo, serum cobalt ion level change; ΔCr, serum chromium ion level change

There were 2 patients in the group 1 with adverse local reactions to metal debris (ARMD) with metal liner wear. Revision arthroplasty was performed with CoM bearing to improve painful symptoms and prevent systemic adverse reactions induced by metal ions debris. Furthermore, other complications include periprosthetic fracture in greater trochanter, which was treated with internal fixation, and postoperative wound infections, which was controlled after simple wound irrigation and debridement.

IV. Discussion

MoM bearing is relatively vulnerable to wear, and CoC bearing has risks of breakage that would require revision operation even though its occurrence is relatively lower. Consequently, CoM bearings has been proposed as a durable alternative treatment option for patients with high physical activity needs.

There have been few direct comparisons of clinical results with the CoM and CoC bearing. As the squeaking incidence of about 10% reported in the previous study (19), the squeaking incidence of CoC and CoM bearing in our study was 11.1% and 15.6%, respectively. In addition, the difference in the squeaking rate between group 1 and 2 was not statistically significant (P = 0.358). The use of CoM bearing is advantageous in expansion in the selection of various sizes of ceramic heads even in a small acetabular cup. In our study, most pateints were performed with THAs using head sizes less than diameters of 36mm, and there is report on statistically lower rates of dislocation on head diameters of 36mm than 28mm (22). It can theoretically reduce dislocation and increase ROM compared to other bearings (23-25).

However, Han et al (26) ironically concluded that the large ROM is the factor that increases the metal ion levels. In addition, there were studies that differential hardness bearing improves fluid film lubrication and reduces adhesive wear and that in vitro studies have proven that differential hardness through a CoM bearing avoids stripe wear (27).

In several previous biomedical and clinical studies, CoM bearing is reported to reduce the metal wear and metal ion release compared to the MoM bearing (10, 28-31). However, the CoM bearings showed the results over a wide range of performance in vivo studies. Affatato et al (12) reported more wears occurred in the CoM bearing than in the CoC bearing, and Reinders et al. (13) no differences in mean wear rates between CoM and CoC bearings.

In this study, the serum ion levels of Co ($P = 0.026$) and Cr ($P = 0.001$) were significantly higher in the group 1 than in the group 2. Han et al (26) demonstrated that serum metal ion levels in the CoM bearings were a 6.5-fold and 9-fold higher in the Co and Cr, respectively, in comparison to non-CoM bearings. In this study, the metal ion levels in the group 1 showed a 5.1-fold higher level of Co and a 6.8-fold higher level of Cr than those in the group 2.

There were significant statistical differences in serum ion level of Co at the postoperative 2nd year ($P = 0.041$) and of Cr at the postoperative 1st year ($P < 0.000$). The patterns of metal ion changes in the 2 subgroups were noted in relation to time with statistical significances (Co: $P = 0.017$; Cr: $P < 0.000$) and showed gradual increases with the number of cycles similar to previous studies (12, 13). The level of serum metal ion increased more than normal in the group 1. It has increased to a similar level to other studies (26, 32) only to the extent without the toxic effect (16). Even though the serum metal ion level did not show any correlations with other variables like age, BMI, surgical factor, acetabular cup position and clinical outcomes, LLC showed positive correlations with both Co ($r = 0.211$, $P = 0.046$) and Cr ($r = 0.281$, $P = 0.007$) serum ion levels. In addition, group 1-B indicated larger serum ion level changes in Co and Cr than group 1-A, and the increase of Cr level in group 1-B showed statistical significance ($P = 0.025$). These results suggest that LLC may affect the functional position of the cup and the edge load. A recent study by Renkawitz et al (33) reported the occurrence of unphysiological gait on patient with more than 5mm leg length difference after THAs. However, there is no established consensus or studies on variability of functional cup position based on leg length, and researches on amount of edge loading due to functional cup position still lack firm evidence. Other studies on risk factors for metal ion releases in CoM bearing suggests BMI and amount of anteversion (34, 35), but these studies did not evaluate LLC.

In this study, there were 2 patients in group 1 who suffered from metal liner wear along with outlier serum metal levels, and both patients received revision arthroplasty with CoC bearings. This result shows that revision rate occurred in only 2 out of 114 (1.8%) cases, which is a good result compared to other studies(36). Their surgical findings revealed massive metal debris with ARMD as well as metal staining in the ceramic head and severe wear at the inferior edge. The LLC were 18.7mm and 14.3mm in first and second patients with revision arthroplasty, respectively. According to the surgical findings, the ceramic head was metal stained, and the taper was relatively clean. Therefore, the metal liner wear on the CoM bearing is considered to be the cause, and the possibility of edge loading due to the difference in leg length before and after surgery is suspected.

There are several limitations to this study. Our study was not conducted with randomization and blinding protocol in all the procedures for surgery and data collection. Therefore, explanations of all the variables utilized in our study are vulnerable to possible inherent biases. There is a problem with the mismatch that the number of patients and the gender ratio between the 2 subgroups. Another limitation is that radiation evaluation is performed by a single radiologist (CYH), resulting in low reliability of the radiological interpretation. In our study, the average value was used after performing 3 repeated measurements in the blind protocol to minimize bias. In addition, the study has a limitation that the confirmation of squeaking depended entirely on the patient's answer. On the other hand, the strength of the study is that 1 skilled orthopedic surgeon operated all patients in the same manner at the 1 institution

V. Conclusion

Our results suggest that CoM bearing THAs show effective hip function in both short-term and mid-term similar to CoC bearing THAs even though serum ion levels of Co and Cr were relatively higher in CoM group and especially higher in patients with LLC more than 1 cm. Therefore, it is critical to minimize LLC less than 1cm during CoM bearing THA operation, and in cases with postoperative LLC more than 1 cm, periodic changes of serum metal ion levels as well as possible clinical symptoms of metal ion toxicity should be carefully examined.

VI. References

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