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Antioxidant System and Ions Concentrations After Femoral Neck and Resurfacing Hip Arthroplasty

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Background: Oxidative stress is a disruption of the pro-oxidative-antioxidant balance, caused by excessive production or ineffective removal of reactive oxygen species.

Material/Methods: The study included 42 male patients aged 38 to 69 years. The first group consisted of 21 men with osteoarthritis after primary hip arthroplasty using the Smith & Nephew Birmingham Hip Resurfacing implant. The second group included 21 men after hip arthroplasty using the femoral neck SPIRON K-implant. In both groups, concentrations of ions, the antioxidant system in the blood, and parameters of oxidative stress were evaluated twice. Clinical assessment using the Western Ontario and McMaster Universities Osteoarthritis Index, Harris Hip Score, and Short Form (12) Health Survey (SF-12) scales was performed.

Results: Concentrations of metal ions in the blood and the level of oxidative stress were significantly higher in the resurfacing group than in the femoral neck arthroplasty group. The response of the antioxidant system was significantly greater in the femoral neck arthroplasty group. During clinical evaluation, groups did not show significant differences, with the exception of greater shortening of the operated limb and a lower score in the mental-sphere of the SF-12 scale in the resurfacing arthroplasty group.

Conclusions: Resurfacing hip arthroplasty increased oxidative stress, increased the concentration of metal ions, and did not affect alignment of the abbreviation of the operated limb. A significant improvement in the quality of life of patients in the mental sphere according to the SF-12 occurred after the application of resurfacing arthroplasty, in the first month after the procedure.

Keywords: Arthroplasty, Replacement, Hip • Chemistry, Clinical • Oxidative Stress

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Background

Osteoarthritis of the hip joints (coxarthrosis) is the second most common location of degenerative changes in patients. In developed countries, it occurs in 3% to 6% of the population, a rate that has remained constant for about 40 years. In Poland, the disease affects around 8% of the population. The gradual destruction of the articular cartilage, bone subcartilage layer, joint capsule, and other tissues surrounding the hip joint causes pain and restricts mobility [1].

Treatment of osteoarthritis depends on the severity of the disease, the patient's response to pain, and disease-related limitations in the activities of daily living. In addition, treatment depends on a patient's age and overall health. Hip arthroplasty is widely recognized as the most effective medical procedure, which is the most effective in relieving pain, increasing joint mobility, and improving patient quality of life [2].

Owing to the constant expansion of indications for hip arthroplasty, as well as to the decreasing age of the operated patients, bone-sparing endoprostheses are increasingly used. The range of implants used is expanding, and surgical procedures are performed in a shorter time [3,4].

Currently, in Germany, resurface arthroplasty represents only 0.9% of all performed hip arthroplasties. According to Klug et al in 2019, based on a 10-year analysis of studies in Germany, over 50% of all performed surgeries were total cementless hip arthroplasty using a classic stem. The database analyzed in the above study did not include the evaluation of femoral neck arthroplasty [5].

The Central Base of Endoprosthesoplasty of the National Health Fund divides endoprosthesoplasty of the hip joint into cemented and cementless, without distinguishing among the latter the type of implant used (classic, epiphyseal, cervical, and reconstructing articular surfaces). In Poland, over 52 000 primary arthroplasties of the hip joint were performed in 2017, of which almost 80% were cemented [6].

Oxidative stress is a disruption of the pro-oxidative-antioxidant balance caused by the excessive production or ineffective removal of reactive oxygen species [7,8]. Superoxide dismutase is an antioxidant enzyme that removes the superoxide radical O_2 by a dismutation reaction. Another antioxidant enzyme, glutathione peroxidase catalyzes the reaction between reduced glutathione and hydrogen peroxide [7-9]. In turn, catalase also breaks down hydrogen peroxide to water [7-10]. The sulfhydryl group of thiol compounds, which is involved in detoxification and antioxidant reactions, is recreated with the participation of the enzyme glutathione reductase [11]. In addition to containing antioxidant enzymes, plasma contains a number of non-enzymatic antioxidants, including uric acid, bilirubin, glutathione, albumin, ascorbic acid, tocopherols, beta-carotene, coenzyme Q, and alpha-lipoic acid [12,13].

Chromium, like nickel and cobalt, is part of metal dental and orthopedic implants, such as hip or knee endoprostheses. These metals are common contact allergens. The pathomechanism of the reaction to metal particles in the tissues around the prosthesis shows damage and repair reactions as well as parallel immunological reactions. These processes are manifested by osteolysis, aseptic necrosis, loosening of the implant, and even necrosis forming pseudotumors [14,15].

The aim of our study was to evaluate the antioxidant system and the concentration of chromium, cobalt, and nickel ions and to assess the clinical status of men who underwent resurfacing and femoral neck hip arthroplasty.

Material and Methods

Ethics Statement

The Bioethical Committee at the Silesian Chamber of Physicians in Katowice gave its approval of the study under resolution no. 9/2014 of 24/02/2014, concerning the medical experiment entitled "Concentration of selected METALS and biochemical indicators in the blood and quality of life after hip arthroplasty (ENDOMETAL project)", which is conducted in agreement with the principles of the Helsinki Declaration of 1975.

Forty-two patients of the District Hospital of Orthopedics and Trauma Surgery in Piekary Śląskie diagnosed with osteoarthritis of the hip joint after primary arthroplasty were included in the study. The inclusion criteria for the study were as follows: patients after unilateral capoplasty (metal-to-metal articulaction) in the course of idiopathic osteoarthritis of the hip and patients after femoral neck arthroplasty with ceramic-to-ceramics configuration; men, age <70 years of age; patients with no evidence of active inflammation, no history of cancer, or mental retardation; operations performed in one medical center; and informed and written consent to voluntarily participate in the study. The exclusion criteria were as follows: patients with a disease other than idiopathic osteoarthritis of the hip joint; female sex; stated active inflammation; history of cancer, mental retardation, or operations performed in another medical center; and no written consent from the patient to participate in the study.

The patients were divided into 2 research groups: Group I included 21 patients undergoing unilateral hip resurfacing arthroplasty using a Smith & Nephew Birmingham Hip Resurfacing (BHR) implant (metal to metal articulation). Group II included 21 patients after unilateral hip arthroplasty using the femoral

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Table 1. Demographic data of the studied group of patients (data presented as means±SD or in%).

Parameter	Femoral neck arthroplasty group (n=21)	Resurface arthroplasty group (n=21)	*P*
Body weight (kg)	89.5±12.1	97.0±17.7	0.169
Height (m)	1.77±0.06	97.0±17.7	0.254
BMI (kg/m^2)	28.6±3.55	30.2±5.27	0.325
Ischemic heart disease	0%	14%	0.075
Hypertension	33%	43%	0.537
Diabetes	0%	5%	0.323

BMI – body mass index.

neck SPIRON K-implant (femoral neck arthroplasty group in a ceramic-on-ceramic configuration).

Table 1 shows the demographic parameters of the study groups.

Implant Systems Used

In the Group I, the BHR system, according to International Standard ISO 5832-4, was used. It has metal-on-metal articulation, consisting of a press-fit socket and a cowl cap, with an orienting indicator placed on the bone cement also by pressing (press-fit). The bushing and pin system is made of chromium, molybdenum, nickel, steel, carbon, magnesium, silicon, and cobalt ions [16].

In the Group II, a cementless Corin press-fit cup with a cervical cementless K-Implant stem using the BIOLOX Delta II ceramic bearing was used [17]. Patients from both groups had 2 visits. In Group I, the first visit took place about 5 years after surgery (mean 58.9 months), in Group II, the first visit was about 3 years after surgery (mean 34 months). The second visit was, on average, 6 months later.

Biochemical determinations were made at the Faculty of Biochemistry, Department of Biochemistry in Zabrze, Medical University of Silesia in Katowice, Laboratory of the District Hospital of Trauma Surgery in Piekary Śląskie and at the Laboratory of Zinc and Lead in Miasteczko Śląskie.

Ceruloplasmin concentration in serum was determined according to Richterich [18], and the sulfhydryl group was determined as described by Koster et al [19]. Total antioxidant capacity and total oxidant status were measured in serum as described by Erel [20]. Lipid hydroperoxides in serum were measured according to Södergren et al [21], and malondialdehyde was measured according to Ohkawa et al [22], with the same modifications. The concentration of lipofuscin was measured according to the method of Tsuchida et al [23].

The activities of superoxide dismutase were measured in serum and erythrocytes according to Oyanagiu [24]. In erythrocytes catalase activity was measured by method of Johansson and Borg [25], glutathione reductase by Richterich [18], glutathione S-transferase (GST) by Habig and Jakoby [26] and glutathione peroxidase by Paglia and Valentine [27].

The concentrations of chromium, cobalt, and nickel in the blood serum were determined using the Atomic Absorption Spectrometer model ICE 3400 (Thermo Fisher Scientific, UK) with a graphite furnace GFS35Z with an automatic sample feeder, and with background correction based on the transverse Zeeman effect and deuterium correction on the QuadLine lamp. The nickel concentration was determined according to Olmedo [28] by measurement at a wavelength of 232 nm, chromium by Huang [29] at a wavelength of 357.9 nm and cobalt by Schwingel Ribeiro at a wavelength of 242.5 nm. Metal concentrations are presented in µg/L [30].

Each patient was also assessed clinically using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Harris Hip Score (HHS) scales, and their quality of life was assessed using the Short Form (12) Health Survey (SF-12). WOMAC is a recognized, multi-dimensional disability assessment and self-assessment tool for osteoarthritis. The best result is 0 points, the worst, 96 points. The HHS scale assesses pain, function, deformity, and joint mobility. A maximum of 100 points can be obtained. The SF-12 scale is a proven and widely accepted tool for assessing the quality of life in the physical and mental sphere. The physical health category includes the following subscales: physical functioning, the role of physical constraints, physical pain, and general health. The mental health category includes vitality, social functioning, the role of emotional constraints, and mental health [31-33].

The physical evaluation also included lower limb length (possible shortening or lengthening of the operated limb) and the efficiency of the hip abduction apparatus in the Trendelenburg

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Table 2. Clinical characteristics of the studied population of patients (data presented as means±SD).

Parameter	Femoral neck arthroplasty group	Resurface arthroplasty group	*P*
Number of months after surgery	34.0±15.3	58.9±7.25	**<0.001**
Age at the time of surgery (years)	44.1±9.0	53.1±9.7	**0.003**
Age at the time of inspection (years)	46.9±9.42	58.6±9.79	**<0.001**
Head size diameter (mm)	38.0±3.79	52.6±1.69	**<0.001**
Cup size diameter (mm)	55.2±2.79	58.6±1.69	**<0.001**
Local reaction (pseudotumor)	0.0%	0.0%	1.000

test. Using a goniometer, mobility was measured: flexion, extension, abduction, adduction, and inward and outward rotation in the hip joint. To test the muscular strength of the quadriceps muscle, the 5-point Lovett scale was used.

Statistical Analysis

MS Excel 2019 and Statistica 10.0 PL Software were used for statistical analysis. The mean and standard deviation (SD) were determined for continuous variables. The Shapiro-Wilk test was used to verify normality. The Levene test was used to verify the homogeneity of variances. The statistical comparisons between the group resurface arthroplasty and the group femoral neck arthroplasty were made using the *t* test or the Mann-Whitney U test, depending on the normality of distribution and homogeneity. A significance level of $P<0.05$ was considered statistically significant.

Results

The incidence of cardiovascular disease and diabetes, as well as body weight, height, and body mass index did not differ between the groups. The age of the patients in the resurface arthroplasty group was significantly higher (**Table 1**).

The sizes of the heads and cups of the endoprostheses differed significantly between the groups and were larger in the resurface arthroplasty group than in the femoral neck arthroplasty group (**Table 2**).

The concentration of ceruloplasmin, total oxidant status, and concentrations of lipofuscin and lipid hydroperoxides were statistically significantly higher in the resurface arthroplasty group than in the femoral neck arthroplasty group at the first visit (by 10%, 23%, 93%, 31%, respectively). The content of the sulfhydryl group was statistically significantly higher in the femoral neck arthroplasty group than in the value found in the resurface arthroplasty group, by 23%, at the first visit. Lipofuscin concentration was statistically significantly higher in the resurfacing arthroplasty group than in the femoral neck arthroplasty group at the second visit, in serum by 92%, in erythrocytes by 130%, and malondialdehyde in erythrocytes by 45%. Serum superoxide dismutase activity was statistically significantly higher, by 11%, in the resurfacing arthroplasty group than in the femoral neck arthroplasty group at the first visit. The activity of glutathione peroxidase (by 24% and 16%) and glutathione reductase (by 22% and 9%) in erythrocytes at the 2 visits was statistically significantly higher in the femoral neck arthroplasty group than in the resurface arthroplasty group.

The activity of catalase in erythrocytes was statistically significantly higher (by 24% and 18% at the 2 visits) in the resurface arthroplasty group than in the femoral neck arthroplasty group (**Table 3**).

The concentrations of the tested metals chromium, cobalt, and nickel in the blood serum were statistically significantly higher (chromium by 229% and 246%, cobalt by 203% and 148%, nickel by 39% and 2% at the 2 visits, respectively) in the resurface arthroplasty group comparison with the femoral neck arthroplasty group (**Table 4**).

In the study, the hip joint was clinically analyzed. We assessed pain intensity as the number of pain spots (as the sum of pain spots located in the following areas: greater trochanter, groin, thigh, knee and anterolateral calf surface); muscle strength using the 5-point Lovett scale; mobility in the hip joint measuring flexion, internal and external rotation, adduction and abduction in the hip joint, and limb length; and other parameters using the WOMAC, HHS, and SF-12 scales. The above clinical parameters did not differ significantly between the groups, except for the shortening of the operated limb and SF-12 in the mental sphere.

Asymmetry as the shortening of the operated limb, was statistically significantly greater in the resurface arthroplasty group than the length of the limb in the femoral neck arthroplasty group during both follow-ups; mean of 52±78 mm vs 36±115

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Table 3. Evaluation of parameters of oxidative stress in the studied groups of patients at individual stages of the study.

Parameter	Femoral neck arthroplasty group	Resurface arthroplasty group	*P*
Visit 1			
SH (µmol/L) – serum	242±45.2	182±47.4	**<0.001**
CER (mg/dL) – serum	39.3±7.09	35.4±6.28	0.073
TAC (mmol/L) – serum	0.97±0.22	0.91±0.10	0.274
TOS µmol/L	9.02±2.91	11.13±3.37	**0.036**
LPH (µmol/L) – serum	4.97±2.01	6.52±1.74	**0.011**
SOD (NU/mL) – serum	19.5±3.35	17.3±1.84	**0.011**
LPS (RF) – serum	887±230	868±240	0.795
MDA (µmol/L) – serum	2.30±0.93	2.26±0.51	0.867
GR (IU/g Hb) – erythrocytes	7.99±1.64	6.23±1.53	**0.001**
CAT (kU/g Hb) – erythrocytes	473±125.7	588±65.3	**0.001**
SOD (NU/mgHb) – erythrocytes	164±31.7	172±27.96	0.415
GPX (IU/gHb) – erythrocytes	59.2±12.31	44.7±4.61	**<0.001**
GST (IU/gHb) – erythrocytes	0.15±0.04	0.19±0.08	**0.020**
LPS (RF/gHb) – erythrocytes	816±381	1572±512	**<0.001**
MDA (µmol/gHb) – erythrocytes	0.41±0.08	0.41±0.04	0.957
Visit 2 – after 6 months			
SH (µmol/L) – serum	273±71.3	235±49.2	**0.047**
CER (mg/dL) – serum	27.7±10.19	38.9±8.71	**<0.001**
TAC (mmol/L) – serum	1.07±0.16	1.06±0.11	0.742
TOS µmol/L	5.83±2.44	7.60±2.57	**0.027**
LPH (µmol/L) – serum	2.63±1.31	3.19±1.48	0.204
SOD (NU/mL) – serum	18.6±4.28	18.8±1.94	0.817
LPS (RF) – serum	445±332	856±205	**<0.001**
MDA (µmol/L) – serum	3.30±1.39	2.81±1.02	0.197
GR (IU/g Hb) – erythrocytes	7.96±1.55	8.70±1.38	0.108
CAT (kU/gHb) – erythrocytes	490±89.8	577±55.7	**0.001**
SOD (NU/mgHb) – erythrocytes	151±16.4	162±20.93	0.054
GPX (IU/gHb) – erythrocytes	67.6±9.03	56.5±5.56	**<0.001**
GST (IU/gHb) – erythrocytes	0.19±0.04	0.19±0.07	0.844
LPS (RF/gHb) – erythrocytes	867±327	1994±382	**<0.001**
MDA (µmol/gHb) – erythrocytes	0.29±0.08	0.42±0.05	**<0.001**

CAT – catalase; Cer – ceruloplasmin; GR – glutathione reductase; GPX – glutathione peroxidase; GST – glutathione S-transferase; LPH – lipid hydroperoxides; LPS – lipofuscin; MDA – malondialdehyde; SH – sulfhydryl; SOD – superoxide dismutase; TAC – total antioxidant capacity; TOS – total oxidant status.

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Table 4. Assessment of concentrations of tested metal ions in the studied groups of patients at particular stages of the study (data presented as mean±SD).

Parameter	Femoral neck arthroplasty group	Resurface arthroplasty group	*P*
Visit 1			
Cr concentration (μg/L)	1.25±1.53	4.11±8.87	**0.001**
Co concentration (μg/L)	0.98±1.05	2.96±3.39	**0.014**
Ni concentration (μg/L)	0.89±0.56	0.91±0.10	**0.023**
Visit 2 – after 6 months			
Cr concentration (μg/L)	1.40±2.75	4.84±8.14	**<0.001**
Co concentration (μg/L)	1.19±1.77	2.94±4.76	**<0.001**
Ni concentration (μg/L)	0.89±0.54	1.23±0.36	0.897

Co – cobalt; Cr – chromium; Ni – nickel.

mm (*P*=0.006). The number of points on the SF-12 in the mental category was statistically significantly higher in the resurface arthroplasty group compared with that in the femoral neck arthroplasty group at the first follow-up visit: 23.4±4.27 vs 20.6±3.76 (*P*=0.032). During the second follow-up visit, 6 months after the first visit, there was no difference between the groups in terms of mental quality of life according to the SF-12 scale: 22.9±3.57; 21.7±3.34 vs 21.7±3.34 (*P*=0.271).

Throughout the observation period, we did not note any differences between the groups in concomitant diseases that could have had an impact on the intensity of oxidative stress.

Discussion

This work analyzes the level of oxidative stress and the efficiency of the antioxidant system. There were significant differences in the activity of the tested enzymes of the antioxidant system between the 2 arthroplasty groups. An increase in activity as a response to the stimulation of the antioxidant system occurred in the resurface arthroplasty group in the case of serum superoxide dismutase, glutathione peroxidase in erythrocytes, and catalase. Glutathione reductase activity in erythrocytes was statistically significantly lower in the resurface arthroplasty group than in the femoral neck arthroplasty group during the first follow-up.

Total antioxidant status was used to assess the non-enzymatic antioxidant system of the blood serum and it did not differ significantly between the 2 groups. However, the higher concentration of sulfhydryl groups in the serum in the femoral neck arthroplasty group may, in turn, be related to the lower activity of glutathione reductase in the resurface arthroplasty group. This study also provided other indirect evidence indicating the stimulation of oxidative processes. One of them was the intensification of lipid peroxidation, expressed by serum total oxidative status, serum lipofuscin concentration, and the concentration of intermediate lipid peroxidation products, such as lipid peroxides and malondialdehyde. Lipid peroxides are formed faster in lipid peroxidation processes than is malondialdehyde; therefore, there was a more pronounced increase in their concentration in the resurface arthroplasty group.

Summarizing this part of the study, it can be stated that metal-on-metal resurface arthroplasty was associated with greater changes in the antioxidant system. The intensified oxidative processes and lipid peroxidation were accompanied by efficient antioxidant defense mechanisms.

The constantly growing number of hip arthroplasties and the increasing percentage of young patients, professionally active and active in everyday life, undergoing surgery explains the constant pursuit of perfection of the implants themselves and the techniques of their implantation. Considerable bone tissue saving and reduction of the number of early dislocations in the group of patients undergoing metal-on-metal resurface arthroplasty appeared to be sufficient arguments for choosing this type of endoprosthesis. It turns out, however, that modular metal-on-metal articulation entails an absolute necessity to monitor the concentrations of metal ions used in their production in the blood serum. In addition, the use of this method also requires periodic radiological control of patients undergoing surgery owing to the potential risk of aseptic loosening of the implant, a reactive reaction, or a pseudotumor. The above-mentioned arguments require qualification of these patients for revision surgery [34-36].

There were statistically significantly higher concentrations of all tested metal ions in the group of patients who underwent

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resurface arthroplasty than in the group who underwent femoral neck arthroplasty in the ceramic-on-ceramic configuration.

Chromium, which is particularly allergenic and readily penetrates biological membranes, is highly redox active. It has been shown, inter alia, that it has the ability to irreversibly inhibit thioredoxin reductase and oxidize thioredoxin. The thioredoxin system is involved in maintaining the correct proportions of the reduced sulfhydryl groups. Smith et al observed a statistically significant increase in the concentration of chromium and cobalt ions in groups of patients after Durom and BHR resurface arthroplasty [37]. These were lower values than those obtained in our study. In the resurface arthroplasty group of the present study, the modular metal head had a diameter that was 4.5 mm larger than that in the Durom or BHR resurface arthroplasty group used by Smith et al. We believe that dimensional differences may have a direct impact on increased serum chromium levels.

Smolders et al analyzed the concentrations of chromium and cobalt ions in a group of 38 patients undergoing surface arthroplasty and a group of 33 patients undergoing classic cementless arthroplasty with a modular metal head. They found a statistically significant increase in the concentration of both examined metal ions in the serum compared with the values before arthroplasty, but without any correlation between the concentration of chromium and cobalt, age and sex of patients, and the dimensions of the prosthetic components [38].

In another study, Subbarao et al observed patients after classical hip arthroplasty using large modular heads for a period of 3 to 6 years. Similarly to the aforementioned study, a statistically significant increase in the concentration of chromium and cobalt ions was observed, but without a significant correlation with the clinical state [39].

In another study, Bisseling et al compared surface and classic cementless arthroplasty with a 28-mm head in a metal-on-metal configuration. In less than 6 years of observation, they found no significant differences between the 2 groups in the clinical assessment. However, the concentrations of chromium and cobalt metal ions in the serum were lower than in many other scientific reports [40].

In a similar work, Delaunay et al concluded that the use of a metal-on-metal bearing with a 28-mm metal head and a Metasul metal insert in classic cementless hip arthroplasty gave very good clinical results in a 15-year follow-up period in patients under 50 years of age. Moreover, none of the observed complications was directly related to the increased concentration of cobalt ion in the serum [41].

Hjorth et al unequivocally proved that the concentrations of chromium and cobalt ions in the serum above 7 μg/L did not lead to, in any way, the occurrence of any negative symptoms in these patients. Moreover, the identified migration of the prosthetic component in the radiostereometric analysis of both the acetabular and the stem components was analogous to that in the group of patients with chromium ions below 7 μg/L [42].

These metals can contribute to the development of aseptic loosening, which gradually affects all the tissues of the joint: the subchondral bone, the cartilaginous surface, the joint capsule, tendons and ligaments, and the synovium. Subsequently, the inflammatory process may affect all soft tissues surrounding the joint, resulting in the formation of a pseudotumor [42,43].

In the present study, no significant differences in clinical assessment were observed between the studied groups of patients. To assess the quality of life, the SF-12 scale was used. We observed no significant differences between the studied groups in the physical sphere, but a statistically significant increase in the quality of life in the mental sphere in the group of patients undergoing resurface arthroplasty was observed. It can be assumed that the younger the age, the greater are the expectations for full recovery, full physical fitness, and professional activity. The higher result for the mental category in the resurface arthroplasty group may have resulted not only from the age difference itself, but also from the time between the operation and the follow-up examination. The resurface arthroplasty group was evaluated almost 2 years later, and perhaps it was the time needed to fully recover and learn to function in the new conditions.

In assessing the quality of life, Smith et al used the SF-36 classification after hip arthroplasty using 3 different implant systems and found no statistically significant differences between the studied groups of operated patients [37].

Similarly, Subbarao et al, assessing the quality of life using the SF-36 classification during the observation period from 3 to 6 years after endoprosthetics in the metal-on-metal configuration using of large heads, did not find statistically significant differences in the assessment of quality of life in the SF-36 classification [39].

Smolders et al used the SF-12 scale in assessing the quality of life of patients qualified for surface and classic arthroplasty with a 28-mm head in metal-on-metal bearing. Even before the surgery, the authors found significantly higher results in the mental health category of SF-12 in the group of patients qualified for surface arthroplasty than in the cervical arthroplasty group. The authors tried to explain this with a greater awareness of the use of "modern" implants, which could have resulted in a better mental attitude toward this surgical procedure. However, the misconception about the negative consequences of classical arthroplasty could directly affect the

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lower mental score of SF-12 even before the classical hip arthroplasty [38].

The limitation of our work was the relatively small number of patients in both study groups due to its comparative nature. At the same time, the performance of a clinical and laboratory test at 2 independent visits, 6 months apart, made it possible to increase the reliability of the obtained results. In this study, only the male sex was assessed owing to the nature of the hospital ward; however, this situation made it possible to ensure the homogeneity of the analyzed group of patients. The observation period could also be extended in future studies.

Conclusions

Arthroplasty of the hip joint in men causes changes in the antioxidant system. BHR resurfacing hip arthroplasty intensifies oxidative stress, most likely due to more intense pro-oxidative processes with a less efficient response of the antioxidant system. It also increases the concentration of metal ions (chromium, cobalt, nickel) in the blood serum but does not compensate for the shortening of the operated limb. Hip arthroplasty, regardless of the implant used, improved the quality of life of patients, as assessed with the SF-12 scale.

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