

Bone & Joint Research

Supplementary Material

10.1302/2046-3758.134.BJR-2023-0188.R1

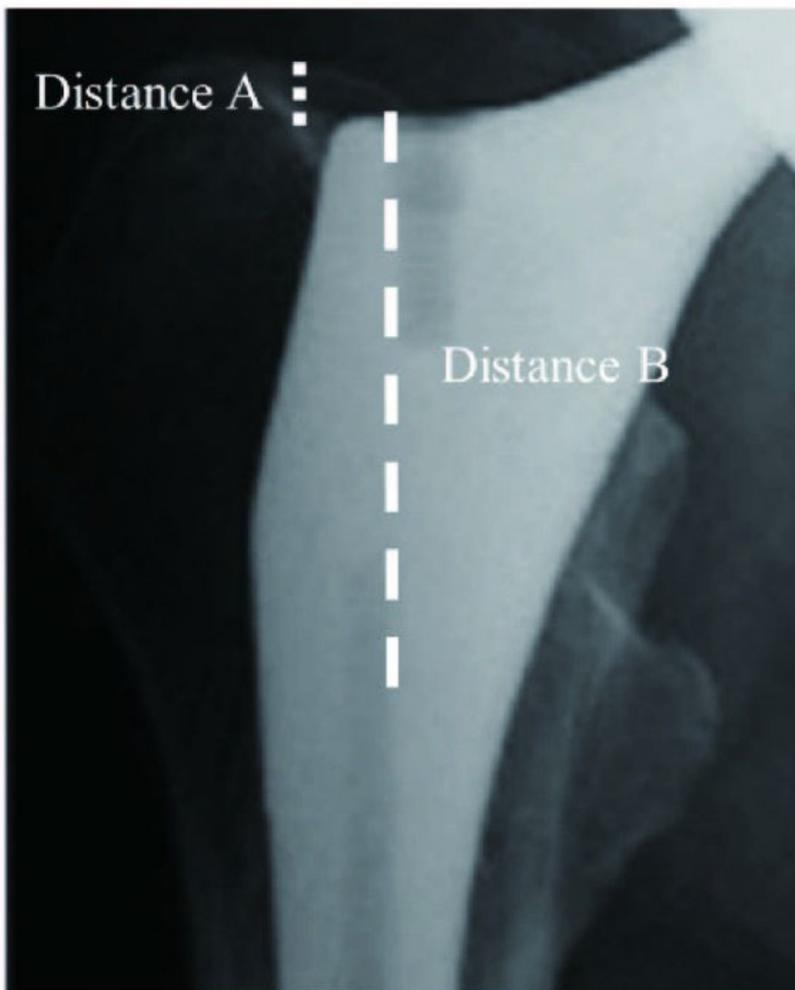


Fig a. Distance A is defined as the distance from the top of the greater trochanter to the stem shoulder, and distance B as the distance from the stem shoulder to the tip of the lesser trochanter.

Calinski.Harabatz Sorted

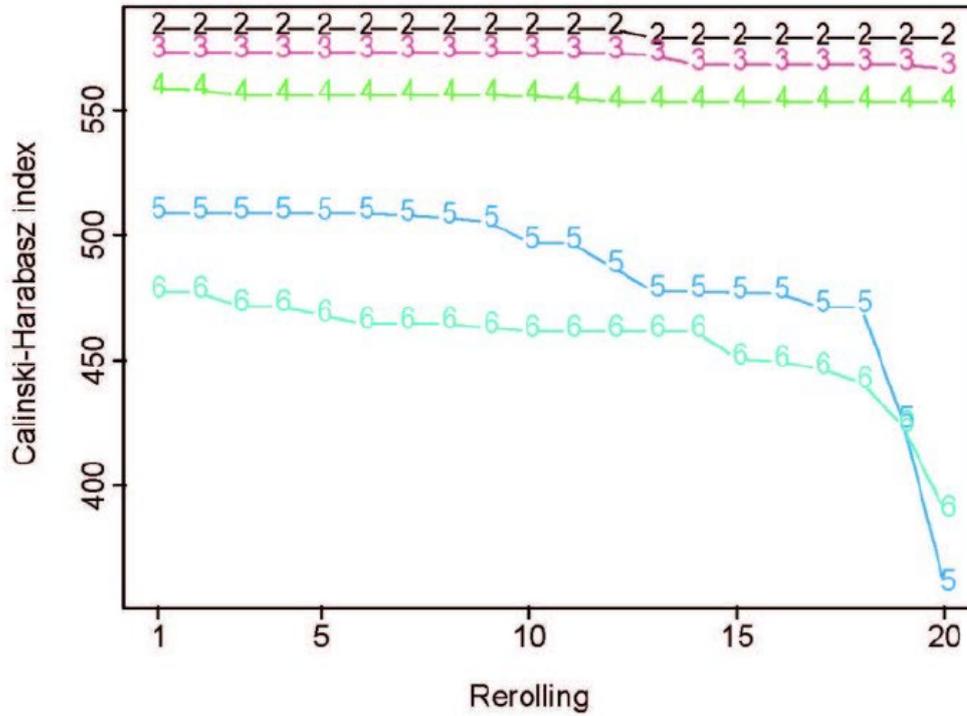


Fig b. Using the statistical criteria proposed by Calinski and Harabasz, we selected the optimal number of clusters in time series clustering from 2 to 6.

Table i. Results of Welch's *t*-test for the difference of predicted probability and binary variables.

Factor	p-value	Adjusted-p-value
Operation side (right/left)	0.560	0.885
Sex	0.797	0.885
Bisphosphonate before THA	0.184	0.851
SERM before THA	0.529	0.885
VD3 before THA	0.607	0.885
Anti-RANKL antibody in first year	0.163	0.851
PTH in first year	0.701	0.885
VD3 in first year	0.949	0.949
Smoking	0.747	0.885
Alcohol	0.179	0.851
PSL	0.309	0.884
Diabetes mellitus	0.715	0.885
Hypothyroidism	0.674	0.885
Chronic kidney disease	0.771	0.885
Asthma	0.213	0.851
Interstitial lung disease	0.309	0.884
RA	0.946	0.949
ONFH	0.631	0.885
RDC	0.111	0.851
CDH	0.426	0.885

CDH, congenital dislocation of the hip; ONFH, osteonecrosis of the femoral head; PSL, prednisolone; PTH, parathyroid hormone; RA, rheumatoid arthritis; RANKL, receptor activator of NF-kappa B ligand; RDC, rapidly destructive coxopathy; SERM, selective oestrogen receptor modulator; THA, total hip arthroplasty; VD3, vitamin D3.

Table ii. Radiological measurements.

Factor	Measurement method
Femoral neck anteversion	The angle between a line passing through the centres of the femoral head and neck and a line passing through the posterior aspect of the femoral condyles.
Stem anteversion	The angle between a line passing through the centres of the bipolar head and stem neck and a line passing through the posterior aspect of the femoral condyles.
Abs error	Absolute difference between stem anteversion and femoral neck anteversion.
Canal flare index	Value of A divided by isthmus.
A	The diameter of the medullary canal 20 mm above the lesser trochanter.
Isthmus	The diameter of the femoral canal at the isthmus.
Preoperative lumbar BMD on the frontal/lateral side	Measured the BMD of the lumbar (L) vertebrae (L2 to L4) in the anteroposterior and lateral directions using DXA at one week pre-surgery.
Dorr classification	Classified the three groups A, B, and C using CFI. Type A is narrow canal with thick cortical walls (CFI more than 4.7). Type B is moderate cortical walls (CFI 3.0 to 4.7). Type C is wide canal with thin cortical walls (CFI less than 3.0).

BMD, bone mineral density; CFI, canal flare index; DXA, dual-energy X-ray absorptiometry.

Table iii. Preoperative peripheral blood tests.

Factor	All (n = 538)			Group A (n = 362)			Group B (n = 176)		
	Mean	Median (IQR)	SD	Mean	Median (IQR)	SD	Mean	Median (IQR)	SD
WBC, / μ l	5,858.7	5,650 (4,700 to 6,800)	1,641.3	5,907.5	5,700 (4,725 to 6,900)	1,642.7	5,758.5	5,550 (4,675 to 6,600)	1,638.5
RBC, 10^4 / μ l	423.7	423 (394 to 452)	44.2	423.6	424 (395 to 452)	44.2	423.8	422 (394 to 453)	44.3
Hb, g/dl	13.04	13.1 (12.2 to 13.8)	1.25	13.00	13.0 (12.3 to 13.7)	1.23	13.12	13.2 (12.2 to 13.9)	1.27
Hct, %	38.44	38.45 (36.13 to 40.80)	3.66	38.37	38.35 (36.30 to 40.70)	3.69	38.59	38.55 (36.08 to 41.00)	3.61
Plt, 10^4 / μ l	24.27	23.6 (20.4 to 27.4)	6.39	23.83	23.35 (20.4 to 26.9)	5.90	25.17	24.65 (20.75 to 29.15)	7.22
TP, g/dl	7.26	7.3 (7.0 to 7.5)	0.46	7.21	7.20 (6.90 to 7.50)	0.44	7.35	7.30 (7.10 to 7.63)	0.49
Alb, g/dl	4.27	4.3 (4.1 to 4.5)	0.31	4.27	4.30 (4.10 to 4.50)	0.31	4.27	4.30 (4.10 to 4.50)	0.32
CK, U/l	97.5	81.0 (59.5 to 114)	64.3	94.9	81 (60 to 112)	56.7	102.9	83 (58 to 115)	77.8
AST, U/l	22.7	21 (17 to 25)	10.3	22.4	20 (17 to 25)	10.2	23.5	21 (17 to 25)	10.6
ALT, U/l	20.1	16 (13 to 22)	16.5	19.5	16 (13 to 20)	16.9	21.2	16 (13 to 23)	15.6
LDH, U/l	193.5	190.5 (168.3 to 213.0)	34.0	193.9	190.0 (169.3 to 212.0)	32.6	192.8	191 (168 to 218)	36.6
ALP, U/l	261.4	255 (201 to 306)	86.8	267.6	258 (204 to 311)	89.2	247.4	241 (191 to 295)	79.67
γ -GTP, U/l	33.0	22 (15 to 33)	43.5	29.1	22 (15 to 32)	26.3	41.0	22 (16 to 33)	65.3
BUN, mg/dl	16.4	16 (13 to 19)	5.04	16.3	16 (13 to 19)	4.84	16.4	15 (12 to 19)	5.44
Cr, mg/dl	0.653	0.61 (0.53 to 0.73)	0.196	0.646	0.61 (0.53 to 0.72)	0.190	0.667	0.63 (0.53 to 0.76)	0.207
eGFR, ml/min/1.73m ²	79.57	77.95 (65.80 to 92.50)	20.13	79.44	77.95 (66.50 to 90.80)	19.98	79.85	78.10 (65.08 to 94.63)	20.50
UA, mg/dl	4.99	4.9 (4.0 to 5.7)	1.27	4.90	4.8 (4.0 to 5.6)	1.22	5.20	5.00 (4.35 to 6.15)	1.34
Glu, mg/dl	111.4	106 (97 to 117)	28.3	110.4	106 (97 to 117)	25.8	113.5	107 (97 to 122)	32.67
T-cho, mg/dl	211.2	208 (187 to 234)	36.3	213.0	209 (187 to 236)	37.4	207.6	206 (186 to 230)	33.87
TG, mg/dl	136.0	113.0 (80.3 to 166.0)	86.0	136.9	115.0 (81.8 to 166.0)	82.4	133.8	108.5 (75.5 to 166.8)	93.9
Na, mmol/l	142.1	142 (141 to 143)	2.12	142.3	142 (141 to 144)	1.89	141.7	142 (140 to 143)	2.48
K, mmol/l	4.14	4.10 (3.90 to 4.30)	0.32	4.14	4.10 (3.90 to 4.30)	0.32	4.14	4.10 (3.95 to 4.30)	0.31

Cl, mmol/l	105.1	105 (104 to 107)	2.31	105.4	105(104 to 107)	2.04	104.5	105 (103 to 106)	2.72
Ca, mg/dl	9.43	9.4 (9.2 to 9.6)	0.37	9.42	9.40 (9.20 to 9.60)	0.37	9.45	9.4 (9.2 to 9.7)	0.39
CRP, mg/dl	0.264	0.08 (0.04 to 0.20)	0.894	0.268	0.08 (0.04 to 0.17)	1.035	0.257	0.10 (0.04 to 0.24)	0.494
APTT, sec	30.57	30.3 (28.3 to 32.3)	3.80	30.55	30.4 (28.2 to 32.4)	3.77	30.59	30.3 (28.4 to 32.3)	3.86
PT-INR	1.021	0.98 (0.95 to 1.02)	0.362	1.006	0.98 (0.95 to 1.02)	0.205	1.051	0.99 (0.95 to 1.03)	0.558
D-dimer, µg/ml	1.363	0.82 (0.50 to 1.55)	1.54	1.367	0.85 (0.50 to 1.63)	1.58	1.355	0.78 (0.50 to 1.35)	1.453

Alb, albumin; ALP, alkaline phosphatase; ALT, alanine transaminase; APTT, activated partial thromboplastin time; AST, aspartate transferase; BUN, blood urea nitrogen; CK, creatine kinase; Cr, creatinine; eGFR, estimated glomerular filtration rate; Glu, glucose; Hb, haemoglobin; Hct, haematocrit test; IQR, interquartile range; LDH, lactate dehydrogenase; Plt, platelet; PT-INR, prothrombin time- international normalized ratio; RBC, red blood cells; SD, standard deviation; T-cho, total cholesterol; TG, triglyceride; TP, total protein; UA, uric acid; WBC, white blood cells; γ-GTP, gamma-glutamyltransferase.

Table iv. Background and clinical scores.

Factors	All (n = 538)	Group A (n = 362)	Group B (n = 176)
Sex (male), n (%)	95 (17.7)	51 (14.1)	44 (25.0)
Mean, median age, yrs (SD; IQR)	63.5, 64.0 (10.9; 55.0 to 72.0)	63.8, 64.0 (10.3; 56.3 to 71.8)	62.8, 63.0 (12.2; 52.0 to 74.0)
Mean, median height, cm (SD; IQR)	156.2, 155.2 (8.24; 150.0 to 161.0)	155.5, 155.0 (7.67; 150.0 to 160.0)	157.5, 157.0 (9.19; 150.0 to 164.3)
Mean, median weight, kg (SD; IQR)	57.86, 56.9 (12.04; 49.0 to 64.0)	56.71, 55.0 (11.03; 49.0 to 62.0)	60.20, 59.1 (13.60; 49.0 to 68.0)
Mean, median BMI, kg/m ² (SD; IQR)	23.64, 23.0 (4.10; 20.9 to 25.9)	23.40, 22.8 (3.94; 20.5 to 25.6)	24.13, 23.4 (4.37; 21.4 to 26.4)
Mean, median JOA (SD; IQR)	50.15, 51.0 (12.69; 42.0 to 59.0)	49.88, 50.0 (12.64; 42.0 to 59.0)	50.7, 53.0 (12.81; 43.0 to 59.0)
Mean, median HHS ¹ (SD; IQR)	55.00, 55.0 (13.79; 46.8 to 65.0)	54.94, 55.0 (13.84; 47.0 to 65.0)	55.14, 56.0 (13.73; 46.0 to 65.0)
Operation side (right), n (%)	291 (54.1)	201 (55.5)	90 (51.1)
Smoking, n (%)	82 (16.1), missing = 28	63 (18.3), missing = 18	19 (11.4), missing = 10
Alcohol, n (%)	177 (34.6), missing = 26	126 (36.4), missing = 16	51 (30.7), missing = 10
PSL, n (%)	59 (11.0)	41 (11.3)	18 (10.2)
Previous medical history, n (%)			
Diabetes mellitus	32 (5.95)	18 (4.97)	14 (7.95)
Hypothyroidism	11 (2.04)	8 (2.21)	3 (1.70)
Hyperthyroidism	5 (0.929)	2 (0.552)	3 (1.70)
Thyroid cancer	3 (0.558)	1 (0.276)	2 (1.14)
Chronic kidney disease	9 (1.67)	6 (1.66)	3 (1.70)
Asthma	14 (2.60)	11 (3.04)	3 (1.70)
Interstitial lung disease	4 (0.743)	2 (0.552)	2 (1.14)
Systemic lupus erythematosus	6 (1.12)	4 (1.10)	2 (1.14)
Rheumatoid arthritis	17 (3.16)	12 (3.31)	5 (2.84)
Pemphigus	4 (0.743)	4 (1.10)	0 (0)
Behcet's disease	4 (0.743)	3 (0.829)	1 (0.568)
Diagnosis, n (%)			
ONFH	58 (10.8)	36 (9.94)	22 (12.5)
RA	5 (0.929)	1 (0.276)	4 (2.27)
SIF	4 (0.743)	2 (0.552)	2 (1.14)
RDC	7 (1.30)	6 (1.66)	1 (0.568)
After_osteotomy_ONFH*	5 (0.929)	1 (0.276)	4 (2.27)

Factors	All (n = 538)	Group A (n = 362)	Group B (n = 176)
CDH, n (%)	99 (18.4)	55 (15.2)	44 (25)
Tönnis classification, n (%)			
I	1 (0.186)	1 (0.276)	0 (0)
II	73 (13.6)	51 (14.1)	22 (12.5)
III	380 (70.6)	262 (72.4)	118 (67.0)
Dorr classification, n (%)			
Missing	10 (1.86)	6 (1.66)	4 (2.27)
1	94 (17.5)	54 (14.9)	40 (22.7)
2	375 (69.7)	254 (70.2)	121 (68.8)
3	59 (11.0)	48 (13.3)	11 (6.25)
Implant, n (%)			
Accolade TMZF	101 (18.8)	48 (13.3)	53 (30.1)
Accolade II	96 (17.8)	70 (19.3)	26 (14.8)
SL-PLUS	52 (9.67)	45 (12.4)	7 (3.98)
SL-PLUS MIA	108 (20.1)	76 (21.0)	32 (18.2)
SL-PLUS MIA HA	85 (15.8)	65 (18.0)	20 (11.4)
VerSys Fiber Metal MidCoat	78 (14.5)	45 (12.4)	33 (18.8)
VerSys Fiber Metal TAPER	18 (3.35)	13 (3.59)	5 (2.84)
Medicine before operation, n (%)			
Bisphosphonate	59 (11.0)	28 (7.73)	31 (17.6)
Anti-RANKL antibody	6 (1.12)	3 (0.829)	3 (1.70)
PTH	2 (0.372)	1 (0.276)	1 (0.568)
SERM	7 (1.30)	5 (1.38)	2 (1.14)
VD3	53 (9.85)	30 (8.29)	23 (13.1)
Medicine in first year, n (%)			
Bisphosphonate	123 (22.9)	60 (16.6)	63 (35.8)
anti-RANKL antibody	13 (2.42)	5 (1.38)	8 (4.55)
PTH	23 (4.28)	14 (3.87)	9 (5.11)
SERM	5 (0.929)	4 (1.10)	1 (0.568)
VD3	86 (16.0)	47 (13.0)	39 (22.2)

*Patient who had a history of osteonecrosis of the femoral head and underwent osteotomy.

CDH, congenital dislocation of the hip; HHS, Harris Hip Score; IQR, interquartile range; JOA, Japanese orthopaedic association; ONFH, osteonecrosis of the femoral head; PSL, prednisolone; PTH, parathyroid hormone; RA, rheumatoid arthritis; RANKL, receptor activator of NF-kappa B ligand; RDC, rapidly destructive coxopathy; SIF, subchondral insufficiency fracture; SERM, selective estrogen receptor modulator; VD3, vitamin D3.

Table v. Background and radiological data.

Factor	All (n = 538)				Group A (n = 362)				Group B (n = 176)			
	Mean	Median	SD	IQR	Mean	Median	SD	IQR	Mean	Median	SD	IQR
Preoperative												
Femoral anteversion angle, °	22.50	22	12.88	14 to 30	21.97	22	12.17	14 to 30	23.66	24	14.30	15 to 31.5
A, mm	45.50	45.78	6.16	41.39 to 49.68	45.21	45.55	6.18	40.90 to 49.58	46.09	46.11	6.08	42.30 to 49.99
Isthmus, mm	11.86	11.58	2.44	10.25 to 13.13	12.02	11.86	2.42	10.34 to 13.21	11.52	11.06	2.46	9.96 to 12.79
Canal flare index	3.97	3.89	0.87	3.38 to 4.46	3.88	3.85	0.81	3.32 to 4.39	4.15	4.02	0.95	3.52 to 4.60
Distance A, mm	6.50	6.53	7.68	0.69 to 11.89	5.57	5.88	7.46	0 to 10.66	8.40	8.03	7.80	3.13 to 13.70
Distance B, mm	49.33	49.6	8.36	44.10 to 54.49	50.03	50.13	8.11	44.97 to 54.70	47.89	47.75	8.68	42.02 to 53.65
Preoperative lumbar BMD on the frontal side, g/cm ²	0.93	0.91	0.19	0.81 to 1.04	0.90	0.89	0.18	0.79 to 1.02	1.00	0.98	0.22	0.85 to 1.13
Preoperative lumbar BMD on the lateral side, g/cm ²	0.64	0.62	0.13	0.54 to 0.70	0.62	0.61	0.13	0.53 to 0.69	0.67	0.65	0.14	0.57 to 0.73
Postoperative												
Stem anteversion, °	32.35	33	11.52	25 to 40	32.12	33	11.44	24 to 40	32.87	33	11.70	27 to 39.5
Abs error, °	12.70	10	10.34	5.0 to 18.0	12.93	10	10.57	4.0 to 19.0	12.19	9.5	9.84	5.0 to 16.0
Peripheral BMD, g/cm²												
1 week after THA (Baseline)	0.99	1.00	0.24	0.82 to 1.14	1.01	1.02	0.22	0.86 to 1.15	0.93	0.95	0.27	0.71 to 1.13
6 months	0.78	0.75	0.26	0.59 to 0.94	0.71	0.69	0.22	0.55 to 0.85	0.91	0.91	0.28	0.69 to 1.09
1 year	0.73	0.71	0.25	0.55 to 0.88	0.66	0.66	0.19	0.52 to 0.79	0.89	0.89	0.28	0.68 to 1.09

Factor	All (n = 538)				Group A (n = 362)				Group B (n = 176)			
2 years	0.71	0.68	0.26	0.53 to 0.86	0.63	0.62	0.19	0.49 to 0.75	0.89	0.88	0.28	0.67 to 1.09
3 years	0.71	0.66	0.26	0.53 to 0.86	0.62	0.61	0.18	0.48 to 0.75	0.88	0.87	0.30	0.63 to 1.08
4 years	0.70	0.66	0.25	0.52 to 0.85	0.62	0.61	0.19	0.48 to 0.75	0.87	0.84	0.29	0.62 to 1.06
5 years	0.71	0.68	0.25	0.53 to 0.85	0.63	0.62	0.19	0.48 to 0.76	0.84	0.85	0.28	0.62 to 1.02
BMD change, %												
6 months after THA	0.79	0.78	0.20	0.66 to 0.90	0.70	0.70	0.13	0.62 to 0.78	0.98	0.95	0.16	0.88 to 1.07
1 year	0.75	0.72	0.21	0.61 to 0.87	0.65	0.65	0.12	0.57 to 0.73	0.97	0.93	0.19	0.86 to 1.04
2 years	0.74	0.71	0.22	0.59 to 0.85	0.62	0.63	0.12	0.55 to 0.71	0.97	0.91	0.20	0.85 to 1.05
3 years	0.73	0.70	0.21	0.59 to 0.84	0.62	0.63	0.12	0.55 to 0.71	0.95	0.92	0.19	0.84 to 1.03
4 years	0.73	0.71	0.22	0.59 to 0.84	0.62	0.63	0.13	0.55 to 0.71	0.95	0.92	0.19	0.83 to 1.03
5 years	0.74	0.71	0.21	0.60 to 0.85	0.62	0.63	0.11	0.56 to 0.71	0.93	0.91	0.18	0.83 to 1.03

Abs error, Absolute difference between stem anteversion and femoral neck anteversion; BMD, bone mineral density; IQR, interquartile range; SD, standard deviation; THA, total hip arthroplasty.

Table vi. Results of Spearman's rank correlation coefficient for the difference of predicted probability and continuous variables.

Factor	Spearman's r	p-value	Adjusted-p-value
Age	0.143	0.108	0.421
Height	0.024	0.788	0.909
Weight	-0.040	0.657	0.845
BMI	-0.054	0.548	0.793
JOA	0.195	0.034	0.207
HHS	0.029	0.762	0.909
Canal flare index	0.170	0.059	0.296
A	-0.116	0.201	0.503
Isthmus	-0.191	0.034	0.207
Femoral anteversion angle	0.060	0.536	0.793
Stem anteversion angle	0.006	0.948	0.982
Abs error	-0.033	0.736	0.909
Distance A	0.003	0.973	0.982
Distance B	-0.003	0.971	0.982
Preoperative lumbar BMD on the frontal side	0.083	0.358	0.644
Preoperative lumbar BMD on the lateral side	0.065	0.473	0.751
TP	0.094	0.293	0.644
Alb	-0.047	0.599	0.793
CK	0.257	0.004	0.048
AST	-0.064	0.477	0.751
ALT	-0.120	0.179	0.476
LDH	0.087	0.334	0.644
ALP	-0.203	0.037	0.207
γ GTP	-0.093	0.302	0.644
BUN	0.120	0.180	0.476
Cr	0.269	0.002	0.034
eGFR	-0.313	< 0.001	0.008
UA	0.054	0.595	0.793
Glu	-0.128	0.150	0.450
Na	-0.147	0.100	0.421
K	0.065	0.467	0.751
Cl	-0.089	0.321	0.644
Ca	-0.091	0.350	0.644
CPR	0.132	0.139	0.445
Cho	0.025	0.779	0.909
TG	-0.445	< 0.001	< 0.001
WBC	0.010	0.915	0.982
RBC	-0.142	0.112	0.421
Hb	-0.062	0.484	0.751
Hct	-0.107	0.229	0.543
Plt	0.052	0.564	0.793
PT-INR	0.137	0.123	0.427
APTT	0.002	0.982	0.982
D dimer	0.009	0.921	0.982

Factor	Spearman's r	p-value	Adjusted-p-value
Predict probability	-0.246	0.005	0.049

Abs error, absolute difference between stem anteversion and femoral neck anteversion; Alb, albumin; ALP, alkaline phosphatase; ALT, alanine transaminase; APTT, activated partial thromboplastin time; AST, aspartate transferase; BMD, bone mineral density; BUN, blood urea nitrogen; Cho, cholesterol; CK, creatine kinase; Cr, creatinine; eGFR, estimated glomerular filtration rate; Glu, glucose; Hb, haemoglobin; Hct, haematocrit test; HHS, Harris Hip Score; JOA, Japanese Orthopaedic Association; LDH, lactate dehydrogenase; Plt, platelet; PT-INR, prothrombin time-international normalized ratio; RBC, red blood cells; TG, triglyceride; TP, total protein; UA, uric acid; WBC, white blood cells; γ -GTP, gamma-glutamyltransferase.

References

1. **Harris WH.** Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am.* 1969;51-A(4):737-755.