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Qualitative and quantitative analysis of post-operative drainage: pilot study

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Surgical drains can be placed after an operation to collect postoperative blood loss. However, these could be overestimated. Indeed, the fluid elapsed after the first postoperative day would no longer be pure blood. An early withdrawal of redon could then be considered.

A monocentric prospective study of 25 patients undergoing total knee or primary hip replacement surgery, for osteoarthritis, was conducted. Redon flow was evaluated in total volume and in composition by the sedimentation study. A qualitative analysis of the content of the redon was also carried out. To compare the elements found in the drained liquid with the blood data, a preoperative and two postoperative blood samples were taken.

18 TKA and 7 THA were included. A qualitative analysis of the postoperative flow of 11 TKA and 5 THA was requested. Decreases of sedimentation volumes and protein levels were found in the drained liquid compared to the blood for both TKA and THA.

Our results tend to prove that on postoperative D1, the liquid drained in the redon would be blood, but that the liquid drained on D2 and D3 would be a mixture of blood and serum. Therefore, the real postoperative blood loss would be overestimated.

Keywords: Total knee arthroplasty, total hip arthroplasty, drain, qualitative analysis.

INTRODUCTION

During an operation, blood losses are difficult to avoid. On the one hand, intraoperative losses are recovered by aspiration during the operation, on the other hand, postoperative losses are drained, thanks to the installation of redon drains. This technique developed by Waugh and Stinchfield in 1961[1] was intended to avoid the formation of postoperative haematomas and infections due to fluid accumulation.

A quantitative evaluation of postoperative drainage has already been reported by several authors. Irisson et al.[2], in 2013, conclude that a large majority (75%) occurs within 24 hours after the intervention and declines considerably thereafter. Fan et al.[3], in 2006, concluded that most of the drainage (71.1%) was observed in the first 6 hours after the operation; 87.6% came from the first 24 hours.

To date, a few studies have focused on the quantitative analysis of the content of these redon-type drains over time. However, no studies on the qualitative analysis of drainage were found in the literature. Such an analysis would be very interesting and could have important clinical implications. Indeed, the composition of the content of redons could be different depending on the postoperative days.

This study chose postoperative drainage for knee and hip replacements as a model, since these are frequent operations in Belgium. In fact, in 2017, 22,981 knee prostheses and 26,505 hip prostheses were implanted[4]. However, the routine use of surgical drains is no longer recommended for hip and knee replacements ("strong recommendation with moderate evidence"). These have no positive effect on the purposes of their intended use, such as for wound infections, heamatomas and wound healing complications[5-8].

In the orthopaedic surgery department of Saint-Pierre hospital, during the installation of surgical drains after knee or hip arthroplasty, it was observed that the quantity of figured elements (EF) settled, taking up by definition red blood cells (RBCs), white blood cells (WBCs) and platelets[9], decreased over the days, even if the total amount in the drain did not change much.

The fluid flowing into the redon would not be pure blood, but a mixture contaminated by synovial fluid, after the first or second postoperative day. Therefore, patients' blood loss over the days would be overestimated.

MATERIALS AND METHODS

The main objective of this study was to determine if the fluid flowing into the redon consists of pure blood or a mixture of synovial fluid. The study also sought to determine if the composition of this mixture varies over time.

For this study, searches were carried out on general search engines and on platforms dedicated to scientific literature. The keywords used were "total knee arthroplasty", "hip arthroplasty", "drainage", "suction" qualitative and quantitative analysis ", their equivalent in French as well as extensions and combinations of these terms.

This study is prospective and monocentric (CHU Saint-Pierre, Brussels, Belgium) and has been accepted by the hospital's ethics committee (reference B076201941685). The study involves patients, over 50 years old, requiring a total knee or hip replacement, between November 1, 2019 and March 15, 2020, and suffering from gonarthrosis or coxarthrosis. Patients taking chronic anticoagulation or having coagulopathy were excluded from the study.

During the operation, for TKA, a tourniquet was always placed at the root of the limb and inflated to a pressure of 300mmHg. The approach first used was medial para-patellar. The prosthesis used was either from *Zimmer*© (cemented Persona) or *DePuy Synthes*® (Attune CR). After tourniquet release, before closing the wound, hemostasis was performed by electrocoagulation. At the end of the operation, the redon was always positioned in the medial para-patellar sulcus and externalized in the supero-external corner of the knee. Postoperatively, treatment with cryotherapy and continuous passive mobilisation (Kinectec®) was applied to all patients.

We also analysed the postoperative THA flows as a point of comparison on postoperative bleeding. For these prostheses, the approach used was the posterior approach. The prosthesis used was from *DePuy Synthes*© (uncemented Coral®). Before wound closure, as with TKA, electrosurgical haemostasis was performed.

For all interventions, the redon used is of the *Privac® 400ml Large-Lock OPS* type, from *Primed*: bottle with a pre-evacuated vacuum of 900mbar and integrated vacuum indicator. On its walls, a large and a small scale allow to determine exactly the quantity passed.

Postoperative flow (total volume and settling volume) was evaluated by reading the redon placed during surgery. This reading was possible visually using the above-mentioned scales. The settling volume is the amount of deposit at the bottom of the redon. A change of redon was done every 24 hours for 72 hours, for a total of three redons. All the redons were kept in a room at constant temperature. For each redon, the total volume and three settling volumes were recorded. The quantitative evaluation of the decantation was done at the time of redon removal - at 6:30 a.m. (^{1st} sedimentation), at 6:30 p.m. the same day (^{2nd} sedimentation) and the next day at 6:30 a.m. (^{3rd} sedimentation), for a total of 9 readings per patient (cf. Fig. 1). Only the last sedimentation was considered in the statistical analyses.

At the same time, three blood tests were taken: one preoperative and two postoperative, on D1 and D3, both taken at 6am. All the blood analysis included a complete haematological examination with a Complete Blood Count (CBC), as well as the determination of proteins and lactate dehydrogenase (LDH) post-operatively, to calculate certain ratios (cf. Fig. 2). A preoperative coagulation examination excluded patients with coagulopathy.

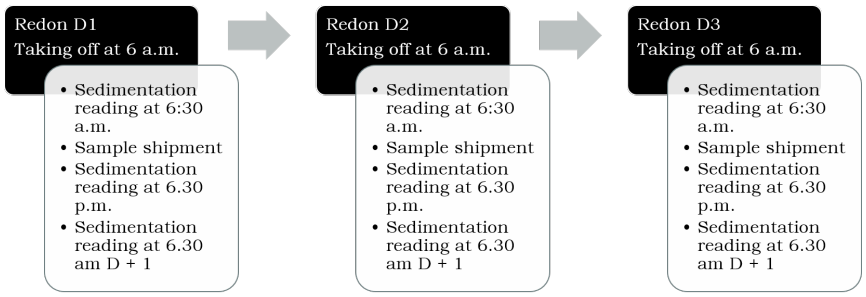


Figure 1. — Procedure for reading and recording drains.

Criteria of Light	Exsudat	Transsudat
Redon/ serum proteins	> 0,5	< 0,5
LDH redon/serials	> 0,6	< 0,6
LDH redon (UI/L)	> 200	< 200

Figure 2. — Extrapolated Light Criteria.

After the first decantation reading of each redon, the contents of it were mixed manually to obtain a non-haemolyzed liquid, sent to the laboratory for qualitative analysis. This allowed us to measure the levels of RBCs, nucleated elements, neutrophils, lymphocytes, proteins and LDH, to highlight a possible difference in the composition of the liquid that passed over the days.

An estimate of the macroscopic haematocrit of the redon, calculated according to the formula below, was used to compare this macroscopic haematocrit with the blood haematocrit on D1 and D3. The purpose of this comparison is to determine whether the fluid flowed has the same percentage of haematocrit as the blood and their respective evolution.

$$\text{Macroscopic heamatocrit (\%)} = \frac{\text{volume 3rd sedimentation (ml)}}{\text{total volume flowed (ml)}}$$

To qualify the fluid according to Light's criteria[10], a quotient was calculated between the redon and serum protein assays and between redon and serum LDH. (cf. Fig. 2).

For statistics, SPSS Statistics 20.0 software was used. Descriptive statistics were calculated for each of the measures. To compare our datasets, non-parametric tests were used. The choice of these tests was guided by the sample size, the research questions, and the characteristics of the groups of data analysed.

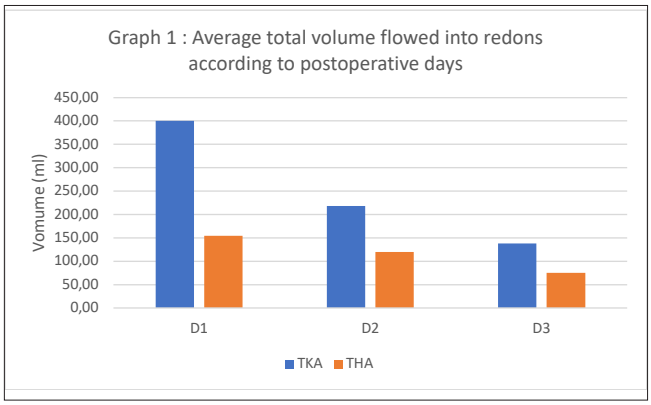
Friedman's tests were carried out to follow the evolution of the different components measured over the days in the redons: measurements from k (= 3) paired samples per patient. Post-hoc Wilcoxon's tests, were also carried out on these same measurements in order to obtain more details on these evolutions: 2 paired samples per patient, with comparisons by couple (D1/D2, D2/D3 and D1/D3). For the TKA vs THA comparison, Mann-Whitney's tests were chosen: comparison of two independent samples.

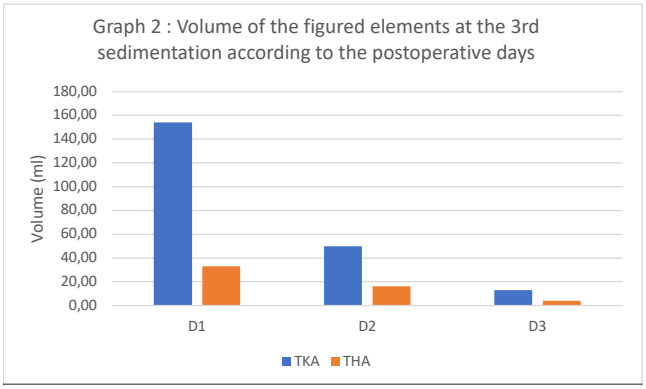
RESULTS

Twenty-five patients were included in this study: 18 TKA (13 women and 5 men) and 7 THA (3 women and 4 men). Among the redons posed, the flow of 11 TKA and 5 THA was analysed in the laboratory. The mean age of these patients was 64.2 ± 9.4 years for TKA and 63.4 ± 6.5 years for THA.

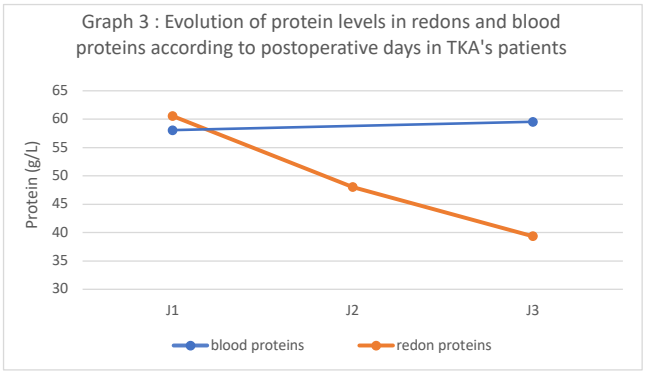
In both TKA and THA patients, a significant decrease in most blood test components measured was demonstrated, between the preoperative and postoperative measurements. WBC and neutrophil counts increase between the preoperative day and the postoperative D1, before falling significantly between days 1 and 3 postoperative. However, the neutrophil dosage decreases significantly only in TKA patients (Appendix I and II). These same tests, applied to the redon analyses, showed a significant decrease in the total volumes (Graph 1), figured elements at the 3rd sedimentation (Graph 2) and proteins (Graphs 3 and 4). Moreover, no correlation was found between the quantities of neutrophils and proteins contained in redon, both in TKA and THA.

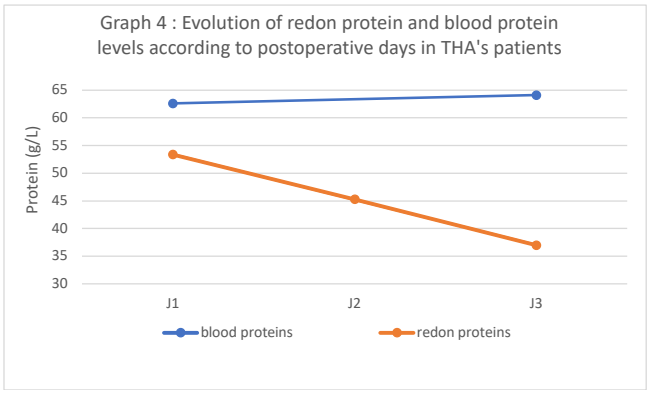
Comparison of the content of redons in TKA vs THA patients (Appendix III) shows, on postoperative D1, statistically significant differences in total elapsed volumes (p = .001), figured elements at 3rd sedimentation (p=.001) and GR (p=.005) and LDH (p=.038) levels.

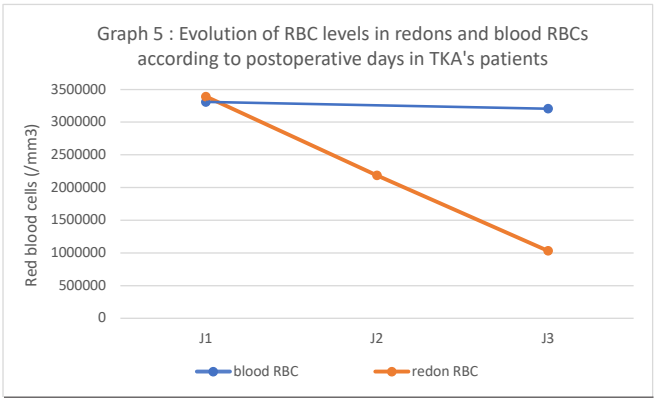


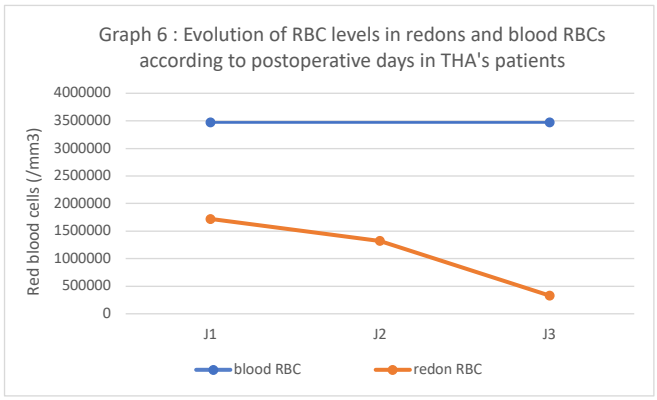


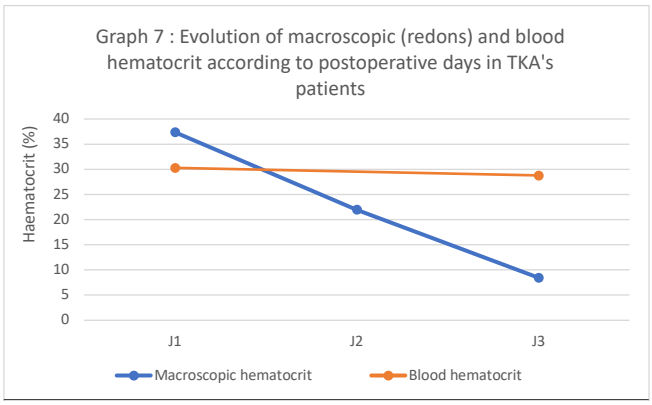
On postoperative D2, these differences are found for the total volumes (p=.034), figured elements at the 3rd sedimentation (p=.021) and the LDH level (p=.006). For the RBC rate, the difference is no longer significant. Finally, on postoperative D3, this comparison shows only one statistically significant difference in the volume of figured elements at the 3rd sedimentation (p=.029), while the difference in the total volume elapsed in the redon is at the limit of significance (p=.055).

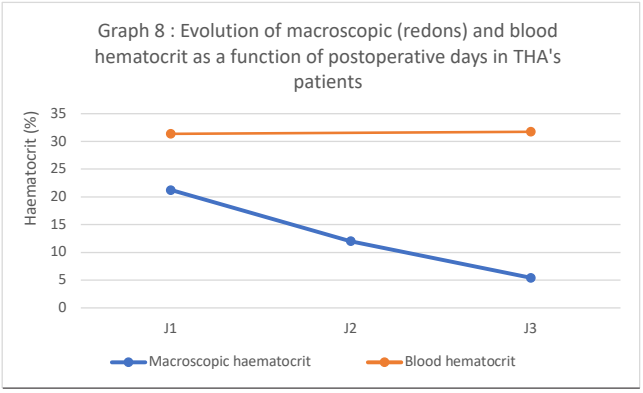












Redon protein / serum protein and redon LDH / serum LDH ratios were calculated, respectively for TKA and THA patients.

For proteins, for TKA, the ratios obtained are 1.03 ± 0.13 on D1, and 0.66 ± 0.13 on D3. For LDH, the ratios obtained are 5.83 ± 1.96 on D1, and 5.28 ± 1.78 on D3.

For THA, the proteins ratios are 0.81 ± 0.05 on D1, and 0.57 ± 0.03 on D3. For LDH, the ratios obtained are 13.43 ± 8.12 on D1, and 8.07 ± 4.16 on D3.

Between the amount of serum proteins and those contained in the redon, for TKA, there is no significant difference on D1 (p = .508) but a significant difference on D3 (p = .003) (Graph 3). For THA (Graph 4), this difference is at the limit of significance (p = .066) on D1 to become significant on D3 (p = .043).

For RBCs, there is no significant difference on D1 (p=.657) but a significant difference on D3 (p=.003) between the quantity of blood and that contained in the redon for TKA (Graph 5). For THA (Graph 6), this difference is significant on both D1 and D3 (p=.043).

Finally, graphs 7 and 8 show a link between the mean values of the macroscopic haematocrit and those of the blood haematocrit in TKA (Graph 7) and THA (Graph 8) patients. Blood haematocrit remains stable between days 1 and 3 postoperatively, for both TKA and THA, while macroscopic haematocrit shows a decrease.

DISCUSSION

From a quantitative point of view, in both groups, the total elapsed volume decreases continuously

over the days, as expected. Indeed, the volumes are respectively, for TKA and THA, 400 ± 157ml and 154 ± 132ml for D1, 218 ± 86ml and 120 ± 119ml for D2, and finally 138 ± 73ml and 75 ± 68ml for D3. Several studies have shown similar results (350-500ml in 24 h) in the harvest of redons for TKAs[2,11-13] while others have shown a more abundant flow in the redon[14,15]. For D2 and D3, most studies showed less flow[2,12,15-17]. However, Cheung et al.[18] observed a higher total flow after 48h (918 ± 290ml). These differences could be explained by methodological variations. For post-THA flow on D1, Irisson et al.[2] and Widman et al.[8] obtain superior results (460 and 1025ml). The difference in THA flow could be due to the small sample size.

This study is innovative because never, in the literature, a qualitative analysis of the content of redons or a study of sedimentation has been conducted. No point of comparison is therefore possible. Examination of the sedimentation after 24 h of rest shows a significant decrease over the days for TKAs, but a drop at the limit of significance for THAs (p_{D1-D3}=.075; p_{D2-D3}=.068). It would be interesting to see if these results are confirmed on a larger sample. This decrease in sedimentation volume could be due to the decrease in blood flow in the redon compared to the total flow, in accordance with our hypothesis.

Following the laboratory analysis, a significant decrease in the RBCs contained in the redon is observed for TKA. In the comparison of blood RBC and redon levels, a significant difference is observed only on D3 (p=.003; Graph 5). The flow would be mostly blood on D1, given the similar number of RBCs in the two fluids. On D3, however, the flow would no longer be pure blood. For THA, both on D1 and D3, the redon RBC's level is significantly lower than that in the blood and decreases between D1-D3 and D2-D3 (p=.043). Although the flow is not only blood on D1, the amount of blood flowing into the redon would decrease over the days.

Physiologically, the synovial protein level is between 5 and 25g/l[19] and the blood protein level is between 57-82g/l[20]. However, the rates found in the redons are 60g/l on D1, 48g/l on D2 and 39g/l on D3 for TKA. In the comparison of blood protein and redon levels, there is a significant difference only on D3 (p=.003). This evolution could be due to the composition of the liquid which would be essentially blood on D1. The redon protein level would therefore approach the blood level. However, on D3, the blood protein level is significantly higher than that of redon. The level of proteins contained in the redon would then approach the synovial protein level, which would tend to confirm our hypothesis. It would have been interesting to perform an electrophoresis of the redon proteins to distinguish whether proteins characteristic of the synovial fluid would be found in the drained fluid. For THA, the protein levels found in the redons are 52g/l on D1, 45g/l on D2 and 36g/l on D3. In the comparison of blood and drain proteins levels, there is a difference at the limit of significance (p=.066) on D1 becoming significant on D3 (p=.043). Although less clear, this decrease could be explained in the same way as for the TKA.

As stated in our hypothesis, the flowed liquid would not be only blood. Indeed, the average protein quotients obtained, according to Light's criteria[21], are, for TKAs, 1.03±0.13 on D1 then decrease to 0.66±0.13 on D3. For THAs, this same ratio is 0.81±0.05 on D1 and 0.57±0.03 on D3. The protein ratio of the blood to itself being equal to 1, the liquid that flows out would be blood on D1, then diluted by exudative serum. For THAs, the ratio being less than 1 from D1, the liquid drained would already be diluted with serum. The ratio of redon and serum LDH is higher than 1, both on D1 and D3 and for both groups. As the LDH level reflects the degree of inflammation in the joint space[22], we can deduce that LDH remains very high following the muscular trauma suffered, for both TKA and THA. This trauma would nevertheless be more important in THA.

Furthermore, for TKA, on D1, the calculated macroscopic haematocrit (37%) does not differ from the blood haematocrit (30%). On D2 and D3 however, a significant drop in macroscopic haematocrit is observed (22% and 8.45%), while blood haematocrit remains stable (29%). Regarding THA, the decrease is less clear. Indeed, macroscopic haematocrit on D1 is 21%, 12% on D2 and 5.5% on D3 for an invariable blood haematocrit (31%). This development could indicate that, in TKA, the liquid initially drained would be assimilated to blood. But from D2 and especially D3, the flow would be a mixture of blood and serum. The more marked decrease in this macroscopic haematocrit in TKA could be explained by a greater serum flow than in THA.

All these data confirm the hypothesis that the fluid flowing on D3 is no longer pure blood but a mixture of synovial fluid and blood. Therefore, the advantage of leaving the redon for more than 24 hours should be reviewed and comes in line with what several studies have already shown[6,16,23].

The main strength of this study is its innovative character, through the qualitative analysis of the drain. In addition, this research allows us to expand our

knowledge of quantitative flow in redons, although this topic has already been discussed a lot in the literature. The limitation of this study is the size of the sample.

CONCLUSION

Our results tend to show that on postoperative D1, the liquid drained into the redon would be blood, but that the fluid drained on D2 and D3 would be a mixture of blood and serum. In fact, all the blood components decrease over the days in the liquid contained in the redon, but the liquid discharged remains important. Therefore, the actual post-operative blood loss would be overestimated, and the usefulness of a drain for more than 24 hours should be reviewed.

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Appendix I

Descriptive statistics and comparison of analysis groups (TKA)

Blood tests

	Day pre-op	D1 postop	D3 postop	χ^2	p-value
Haemoglobin (g/L)	13.18[a] (1.80)[b]	9.84 (1.89)	9.47 (1.59)	23.02[c]	***<.001***[d]
RBCs (/mm3)	4483333.33 (496162.74)	3311111.11 (533456.87)	3206666.67 (457426.51)	23.59	***<.001***[d]
WBCs (/mm3)	9137.22 (12179.12)	9602.78 (2417.25)	7654.67 (1925.03)	17.73	***<.001***[d]
Neutrophil (/mm3)	3161.67 (732.13)	7054.44 (2427.80)	4710.56 (2050.89)	10.33	***.006***[d]
Haematocrit (%)	39.65 (4.60)	30.29 (5.55)	28.79 (4.53)	22.80	***<.001***[d]
Protein (g/L)	-	58,07 (3,65)	59,54 (3,58)	-	-
LDH (IU/L)	-	232,63 (34,04)	234,67 (33,54)	-	-

Redundancy analyses

	Redon D1	Redon D2	Redon D3	χ^2	p-value
Total volume drained (mL)	400.56[a] (157.50)[b]	217.78 (86.13)		31.63[c]	***<.001[d]***
Volume of the figured elements (3rd sedimentation)	154.17 (75.07)	49.72 (36.60)	12.89 (16.06)	33.55	***<.001[d]***
RBCs (/mm3)	3393645.45 (1114295.71)	2187481.82 (1427328.68)	1031109.09 (812724.10)	18.73	***<.001[d]***
Nucleated elements (/mm3)	7459.09 (8114.51)	5910.82 (4465.66)	4111.73 (3194.98)	3.46	.178
Neutrophils (/mm3)	6354.91 (7234.43)	5047.27 (4152.49)	3631.73 (2803.91)	2.18	336
Protein dosage (g/L)	60.55 (6.83)	48.03 (7.87)	39.35 (7.36)	22.00	***<.001[d]***
LDH (IU/L)	1306.91 (469.10)	994.64 (303.24)	1207.27 (322.32)	3.46	.178

[a] *mean;* [b] *standard deviation;* [c] *value from χ2 in Friedman's test;* [d] *significant at α=.05.*

Descriptive statistics and comparison of analysis groups (THA)

Blood tests

	J1 pre-op	J1 postop	J3 postop	χ^2	p-value
Haemoglobin level (g/L)	13.40a (1.41)[b]	10.44 (1.20)	10.47 (1.27)	8.07c	***.018d***
RBCs (/mm3)	4485714.29 (481070.24)	3471428.57 (471572.85)	3471428.57 (576524.89)	10.16	***.006***
WBCs (/mm3)	6120.00 (919.33)	10460.00 (2750.01)	8975.71 (2315.81)	5.43	**.066**
Neutrophil (/mm3)	4140.00 (690.94)	7288.33 (2848.39)	5881.43 (2545.31)	2.67	.264
Haematocrit (%)	40.06 (2.99)	31.37 (3.15)	31.74 (3.86)	7.71	***.021***
Protein (g/L)	-	62,62 (4,04)	64,13 (3,29)	-	-
LDH (IU/L)	-	225,67 (46,05)	222,71 (61,05)	-	-

Redundancy analyses

	Redon J1	Redon J2	Redon J3	χ^2	p-value
Total volume drained (mL)	154.00[a] (131.73)[b]	120.00 (119.02)	75.00 (68.25)	5.48[c]	***.065[d]***
Volume of figured elements (3rd sedimentation) (mL)	32.86 (33.87)	16.29 (23.28)	4.00 (7.98)	5.82	***.055***
GR dosing (/mm3)	1721180.00 (466787.70)	1323960.00 (1151531.74)	330500.09 (221353.86)	7.60	***.022***
Nucleated elements (/mm3)	4429.80 (2235.66)	9612.20 (8475.73)	5336.00 (4987.04)	1.60	.449
Neutrophils (/mm3)	4057.80 (2153.03)	8845.60 (8318.49)	5155.00 (4864.13)	1.60	.449
Protein dosage (g/L)	51.65 (6.18)	45.30 (9.86)	35.80 (2.72)	6.50	***.039***
LDH (IU/L)	2891.00 (1390.50)	2059.00 (887.61)	1207.27 (322.32)	2.00	.368

[a] *mean;* [b] *standard deviation;* [c] *Friedman's χ2 value;* [d] *p-value (significant if < .05; limit of significance at .05 < α < .10)*

Appendix II

Pair-wise comparison of data groups (TKA)

Blood tests

	Day pre-op / D1 post-op	Day pre-op / D3 post-op	D1 postop / D3 postop
Haemoglobin level	-3.73[a] **(<. 001)**[b]	-3.41 **(.001)**	-.79 (.432)
RBCs	-3.73 **(<.001)**	-3.41 **(.001)**	-.91 (.361)
WBCs	-2.94 **(.003)**	-1.59 (.112)	-2.90 **(.004)**
Neutrophil	-2.20 **(.028)**	-2.20 **(.028)**	-2.90 **(.004)**
Haematocrit	-3.73 **(<.001)**	-3.41 **(.001)**	-.74 (.460)
Protein	-	-	-1.62 (.105)
LDH	-	-	-.17 (.865)

Redundancy analyses

	Redon D1/ Redon D2	Redon D1/ Redon D3	Redon D2/ Redon D3
Total drained volume	-3.64[a] **(<. 001)[b]**	-3.73 **(<.001)**	-3.43 **(.001)**
Volume of the figured elements (3rd sedimentation)	-3.64 **(<.001)**	-3.72 **(<.001)**	-3.62 **(<.001)**
RBCs	-2.4 **(.013)**	-2.93 **(.003)**	-2.93 **(.003)**
Neutrophil	-.533 (.594)	-.078 (.328)	-1.689 **(.091)**
Protein	-2.93 **(.003)**	-2.93 **(.003)**	-2.94 **(.003)**
LDH	-2.401 **(.016)**	-.622 (.534)	-1.689 **(.091)**
[a] *Z-value in the Wilcoxon test;* [b] *p-value (significant if < .05; limit of significance at .05 < α < .10).*			

Pair-wise comparison of data groups (THA)

Blood tests

	Day pre-op/ D1 post-op	Day pre-op/D3 post-op	D1 postop/D3 postop
Haemoglobin level	-2.37[a] **(. 018)[b]**	-2.20 **(.028)**	0.00 (1.000)
RBCs	-2.37 **(.018)**	-2.20 **(.028)**	-.27 (.785)
WBCs	-2.20 **(.028)**	-2.20 **(.028)**	-1.18 (.237)
Haematocrit	-2.37 **(.018)**	-2.20 **(.028)**	-.17 (.866)
Protein	-	-	-.94 (.345)
LDH	-	-	-1.15 (.249)

Redundancy analyses

	Redon D1/ Redon D2	Redon D1/ Redon D3	Redon D2/ Redon D3
Total drained volume	-.73[a] (. 463)[b]	-1.78 **(.075)**	-2.02 **(.043)**
Volume of the figured elements (3rd sedimentation)	-1.36 (.173)	-1.78 **(.075)**	-1.83 **(.068)**
RBCs	-.67 (.500)	-2.02 **(.043)**	-2.02 **(.043)**
Neutrophil	-1.483 (.138)	-.135 (.893)	-1.214 (.225)
Protein	-1.46 (.144)	-2.02 **(.043)**	-1.83 **(.068)**
LDH	-1.461 (.144)	-1.483 (.138)	-1.095 (.273)
[a] *Z-value in the Wilcoxon test;* [b] *p-value (significant if < .05; limit of significance at .05 < α < .10).*			

Appendix III

Inter-group comparison of TKA and THA redons

	Redon D1	Redon D2	Redon D3
Total drained volume	12.0[a] **(. 001)[b]**	28.5 **(.034)**	31.5 ***(.055)***
Volume of the figured elements (3rd sedimentation)	11.5 **(.001)**	25.0 **(.021)**	27.0 **(.029)**
RBCs	4.0 **(.005)**	18.0 (.320)	14.0(.145)
Nucleated elements	22.0 (.583)	23.0 (.661)	24.0 (.743)
Neutrophils	22.0 (.583)	22.0 (.583)	23.0 (.661)
Protein	11.0 ***(.069)***	18.0 (.661)	24.0 (.743)
LDH	9.0 **(.038)**	2.0 **(.006)**	19.0 (.377)
[a]*Mann-Withney's U-value;* [b]*p-value (significant if < .05; limit of significance at .05 < α < .10)*			