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Orthostatic retractor placement reduces operating time and post-operative inflammatory response during the learning curve of anterior approach THA☆

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ABSTRACT

Introduction: Handheld retractor placement (HHRP) is prone to repetitive repositioning. This could lead to muscle damage especially during a procedure with a steep learning curve. In an attempt to minimize retractor repositioning during the learning curve of direct anterior approach (DAA) total hip arthroplasty (THA), we used a table mounted orthostatic retractor placement (ORP) device.

Purpose: To investigate whether ORP would reduce the extent of muscle damage, OR-time and post-operative inflammatory response.

Materials and methods: 29 Patients were operated by 2 surgeons who randomly used HHRP or ORP during their learning curve of DAA THA. There were 14 patients in a control group who were operated by an experienced surgeon. Blood levels of Creatine Kinase (CK), C-Reactive Protein (CRP), Hemoglobin (Hb), Lactate Dehydrogenase (LDH) and Erythrocyte Sedimentation Rate (ESR) were measured at 1 h pre- and 24 and 48 h post-operatively.

Results: The mean OR-time was 67 and 50 min in the HHRP and ORP cohort, respectively ($p < 0{,}001$). Post-operative CRP levels were significantly higher in the HHRP cohort at 24 h (HHRP 60.64 mg/L (25.20–143.20); ORP 34.67 mg/L (9.30–71.20)) ($p = 0.003$) and 48 h post-operatively (HHRP 154.54 mg/L (65.90–369.00); ORP 81.60 mg/L (21.30–219.40) ($p = 0.004$). The post-operative Hb-levels were significantly lower in the HHRP cohort at 24 h (HHRP 11.11 g/dL (9.10–12.30); ORP 11.37 g/dL (8.80–14.00)) ($p = 0.0008$) and 48 h (HHRP 10.86 g/dL (9.50–12.00); ORP 11.25 g/dL (8.60–14.10)) ($p = 0.03$). Post-operative ESR levels were significantly higher in the HHRP cohort 48 h post-op (HHRP 45.21 mm/h (14.00–83.00); ORP 23.73 mm/h (2.00–73.00)) ($p = 0.004$). No significant differences were found for the CK and LDH levels at any time post-operatively. There were no complications in any group.

Conclusion: The use of an orthostatic retractor placement device allows for reducing the OR-time, post-operative blood loss and post-operative inflammatory response during the learning curve of DAA THA.

1. Introduction

Total hip arthroplasty (THA) is a well-established and successful treatment for end-stage osteoarthritis of the hip.[1] The 2010 prevalence of total hip replacement in the total U.S. population was 0.83%.[2]

The Direct Anterior Approach (DAA) is increasingly popular due to good functional outcomes and short hospital stays.[3–7] However, the DAA has been associated with a steep learning curve that is expected to be around 50 to 100 cases.[8–12] Prolonged OR-times, increased blood loss and a substantial intra-operative complication rate can be expected during the learning curve.[8–12] The introduction of a new procedure is associated with many new variables for the surgical team. One of those variables is retractor placement which can be a burden especially when the procedure is prolonged.

Stable retractor placement is however crucial for an optimal view during component insertion. Most often retractors are held in place by one or more assistants. One of the downsides of handheld retractor placement (HHRP), is that multiple retractor repositioning is often required due to fatigue of the assistant. This could lead to repetitive muscle damage and increased OR-times. As an alternative to HHRP, one

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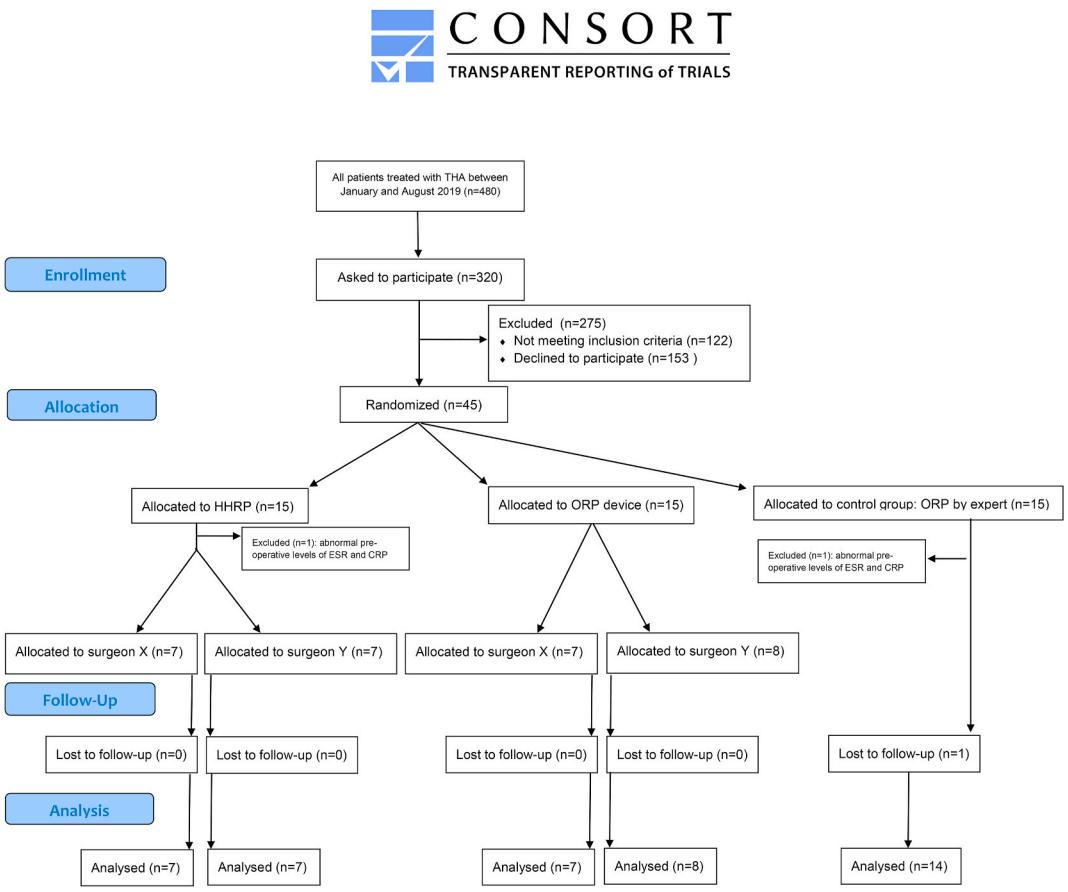

Fig. 1. Consort diagram.

could use orthostatic retractor placement (ORP) devices. These devices allow for a stable retractor placement which remains under full control of the surgeon throughout the full procedure. This could be beneficial during prolonged procedures, such as is often the case during the learning curve of a new surgical technique.

We investigated whether the use of an ORP device would have an impact on intra-operative and immediate post-operative clinical parameters during the learning curve of DAA THA. We also investigated how these learning curve parameters would compare to those of an experienced surgeon.

2. Materials and methods

To date, the DAA THA with the ORP device is standard of care at our institution. In a retrospective analysis at our service, the post-operative CRP level in 99 DAA THA patients operated with HHRP was 69 mg/L. The post-operative CRP level in 100 patients operated with an ORP device was 51 mg/L. Based on this retrospective study, a power analysis with a power of 0,80 calculated a sample size of 15 patients in each cohort would be sufficient.

In total 480 consecutive patients with primary, end-stage osteoarthritis of the hip were treated at our Hip Unit service with a direct anterior approach (DAA) THA between January and August 2019.320 Patients between 40 and 70 years old were requested to participate in a randomized controlled trial (**Fig. 1**). Exclusion criteria were BMI >35 kg/m^2, dysplasia, post-traumatic arthritis, contralateral THA <6 months post-operatively, bilateral THA, known inflammatory systemic disease and abnormal pre-operative blood samples. Written informed consent was obtained from all participants. The protocol was approved by the Medical Ethical Committee of the hospital (Eudract/B-nr: B37 1201 838 189). Initially, 30 patients agreed to participate. After the consent and randomization, there was 1 drop-out due to abnormal pre-operative ESR and CRP levels of unknown cause, leaving 29 patients. Patients were blinded to a random allocation: the procedure conducted with HHRP (N = 14) or with the ORP device (N = 15). Each surgeon conducted, after randomization, 7 DAA cases with HHRP and 7 (X) and 8 (Y) cases with the ORP device. Both surgeons were considered to be in their learning curve for DAA and had followed a dedicated training program including cadaver training. Under the direct supervision of an expert surgeon, they had conducted respectively 9 (X) and 10 (Y) DAA cases prior to the initiation of this study. For the safety of the patients, the procedures were conducted in the presence of the expert surgeon who was not scrubbed in and did not physically intervene with the procedure (Insert Fig. 1).

All patients were premedicated with Midazolam 1–2 mg and Ketanest 5 mg. Thereafter they received spinal anesthesia with isobaric Bupivacaine 10 mg (<175 cm) or 12.5 mg (>175 cm). All patients received an ultrasound guided fascia iliaca block with 30 mL of Bupivacaine 0.25%. Cefazoline 2 g IV or Clindamycin 600 mg IV were provided along with 1,5 g Tranexamic acid IV, 30 min prior to incision. Intra-operative multimodal analgesia consisted of Paracetamol 1 g IV, Ketorolac 30 mg IV, Dexamethasone 5 mg IV and Ondansetron 4 mg IV. Patients received continued oxygen administration through facemask 6L. Postoperatively, patients received Piritramide IM/IV titration per 2 mg (NRS > 4) and a bladder scan with single bladder catheterization if needed.

The procedure was conducted on a regular OR table, in supine position without traction or femoral hyper-extension (Fig. 2). A groin crease incision was used in all cases. In brief, the procedure consists of 3 major parts: capsular exposure, capsular release and component insertion. The Hueter interval between the tensor fascia lata and the rectus femoris is used. The anterior capsule is exposed by means of 4 peri-

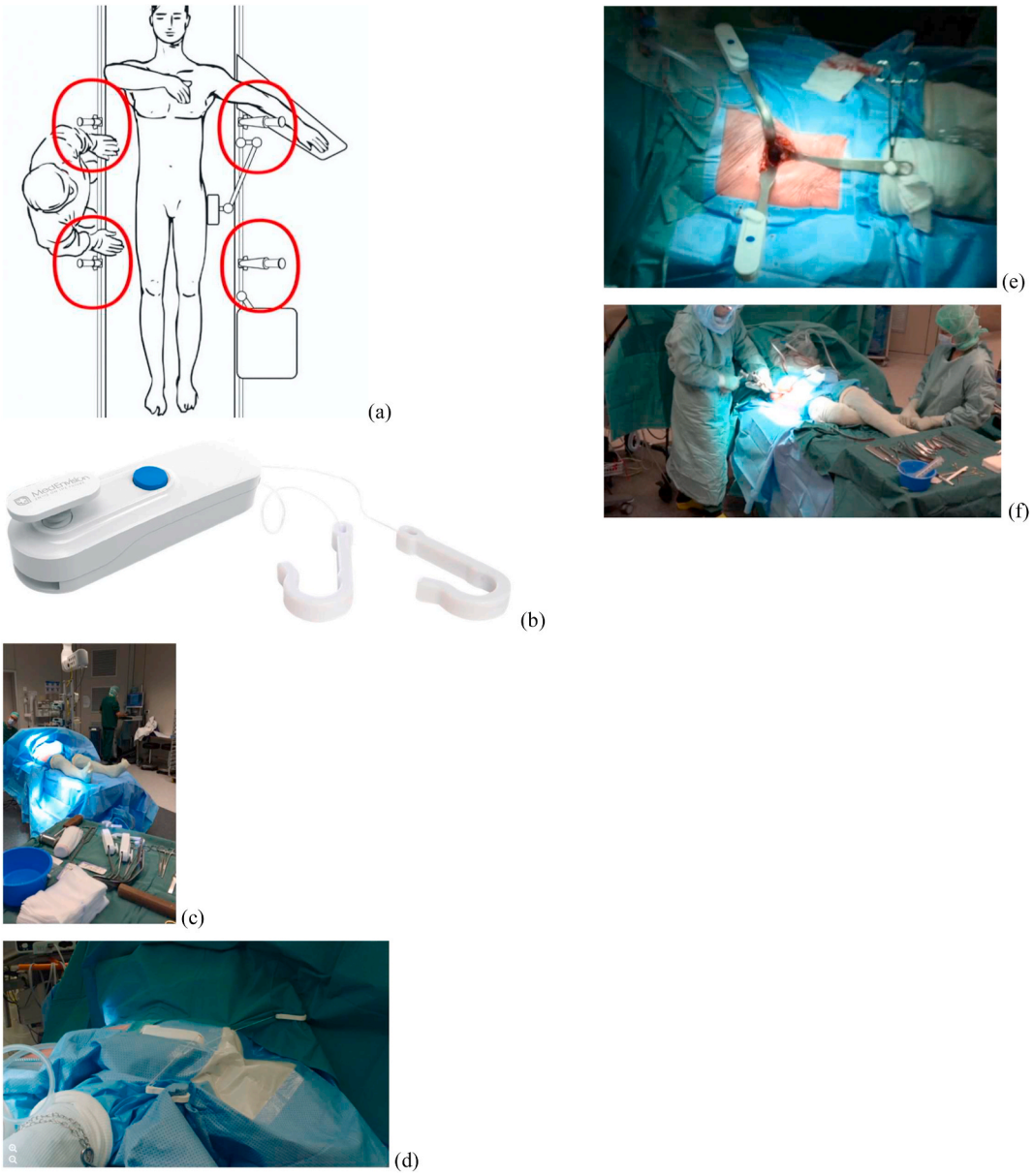

Fig. 2. (a) The patient is installed supine on a regular OR table with both legs draped free. This allows for easy leg length and stability testing at the end of the procedure. (b) The retractors are held in a stable position by the ORP device (Gripper™, MedEnvision, Belgium). (c) The surgeon can conduct the procedure with the help of 1 scrub nurse, even for the femoral broaching. After the stepwise capsular releasing sequence, the femur can be sufficiently elevated so that hyperextension is not required. The surgeon can conduct the surgery with the scrub nurse on the contra-lateral side of the table.

capsular retractors (Fig. 3). The capsular release exists of an anterior capsulotomy followed by the femoral head extraction (Fig. 4). Next the pubofemoral ligament is released followed by the release of the superior capsule. An anterior, posterior and postero-inferior retractor provide an excellent acetabular view for acetabular component insertion (Fig. 5). A superior, medial and lateral retractor provide an excellent exposure of the adducted femur in neutral extension (Fig. 6). Finally, the capsule and fascia are closed with Vicryl 2. In all patients, an uncemented socket (Pinnacle, DePuySynthes, Warsaw, IN) and a cementless stem (Corail, DePuySynthes, Warsaw, In) were used. The procedure is conducted with 1 surgeon and 1 scrub nurse in case the ORP device (Gripper™, MedEnvision, Belgium) is used. The procedure is conducted with 1 surgeon, 2 assistants and 1 scrub nurse in case the HHRP is used. Physiotherapy with full weight bearing was initiated on the first post-operative day. All patients were discharged at day 2 post-operatively (Insert Figs. 2–6).

Preoperative blood samples with Creatine Kinase (CK), C-Reactive Protein (CRP), hemoglobin (Hb), Lactate Dehydrogenase (LDH) and Erythrocyte Sedimentation Rate (ESR) were taken 1 h before the procedure. Blood samples were taken again 1 h, 24 h and 48 h post-operatively. Before skin closure, the damage on the muscle belly of the tensor fascia lata was assessed according to the following classifications[1]: grade 1: superficial anterior muscle fiber interruption,[2] grade 2: anterior muscle fiber gap <5 mm depth and[3] grade 3: anterior muscle fiber gap >5 mm. Component position was measured on postoperative plain X-rays of the pelvis by an independent, blinded investigator. The inclination and the anteversion of the socket were measured as described by Lewinnek [(13)]. The femoral component alignment relative to the femoral shaft axis was also measured. All these measurements were done twice with an interval of three weeks. The mean of both measurements was taken. The Harris Hip Score (HHS) and the Hip disability and Osteoarthritis Outcome Score (HOOS) were evaluated preoperatively, six weeks, three months and six months postoperatively.[14]

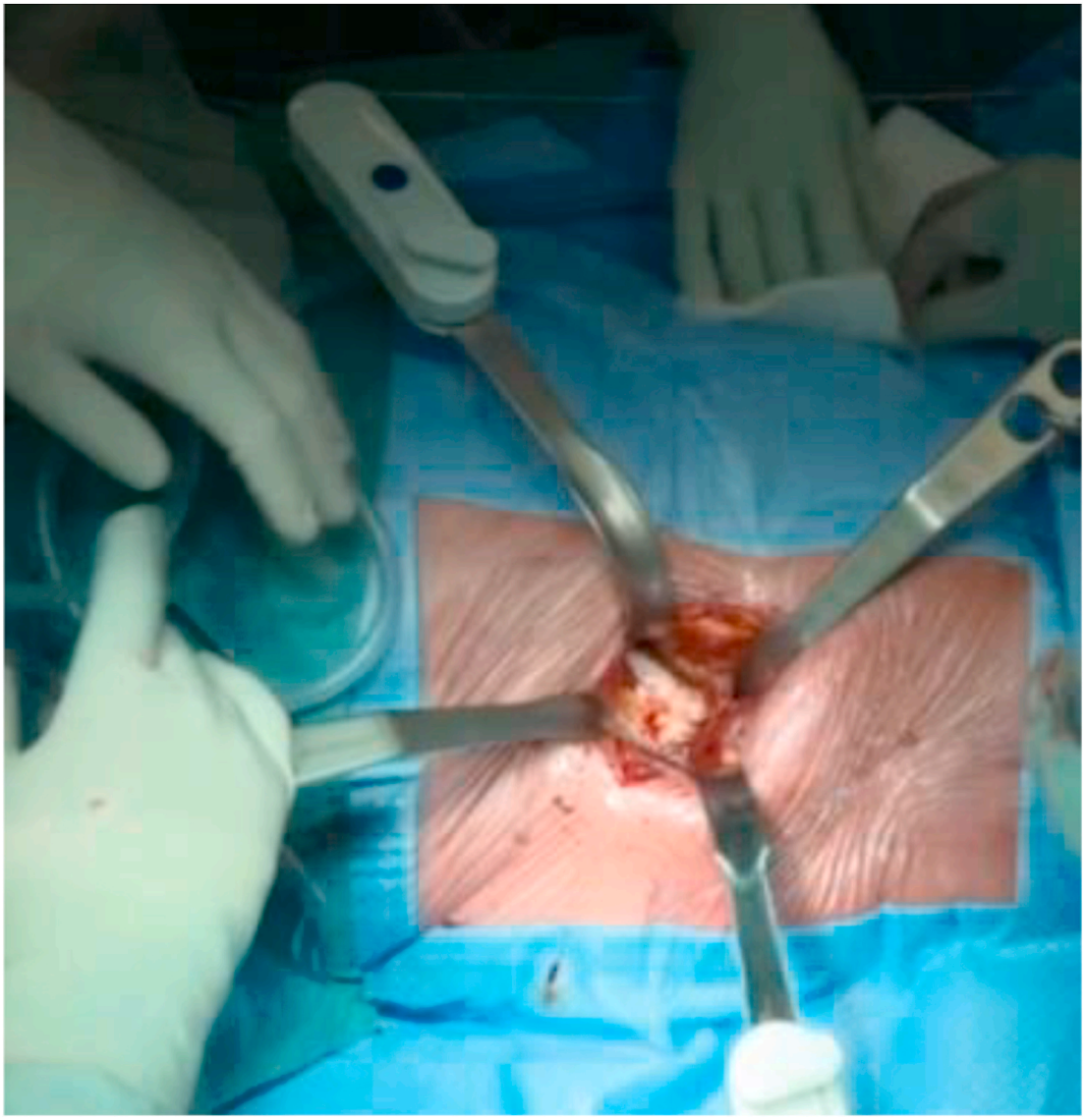

Fig. 3. The anterior capsule is exposed by means of 4 retractors.

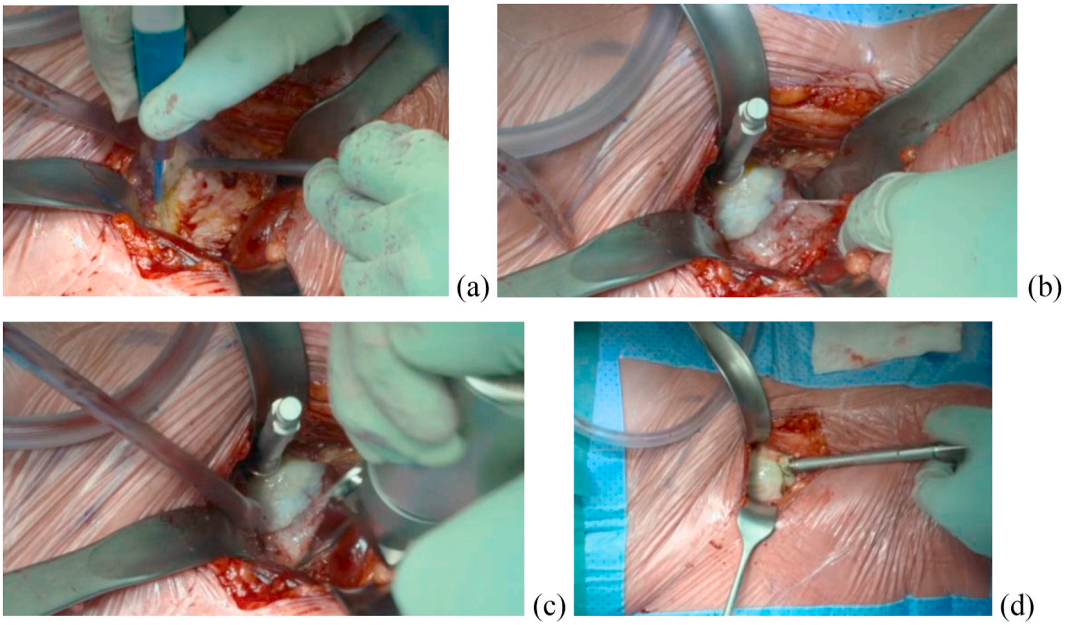

Fig. 4. (a) The anterior flap is created and (b) the corkscrew is put inside the femoral head. (c) The neck is osteotomized and (d) the head is extracted.

During the study period, a control group of 15 patients with the same in-exclusion criteria were operated at our service by an experienced surgeon who had conducted >1300 DAA THA with the same surgical technique and ORP device. Patients agreed to have the same pre- and post-operative follow-up protocol. One patient was excluded from the control cohort due to abnormal pre-operative ESR and CRP levels of unknown cause.

Mean and standard deviation were calculated. For group comparison, the mean difference with 95% confidence interval were calculated and tested using one-way ANOVA. Correlation was tested by using the Pearson correlation coefficient. Statistical analysis was performed using SPSS version 25 (IBM SPSS, Chicago, IL). p-Values less than 0.05 was considered statistically significant.

3. Results

Patient demographics are shown in Table 1. The mean operation time (i.e. time from incision to skin closure) was significantly different between all groups ($p < 0.0001$). The mean duration of the procedure was significantly longer in the HHRP group (67 ± 10.32 min) compared to the ORP group (47 ± 7.71 min). The OR time in the control group was 34 ± 8.29 min ($p < 0.0001$). All patients were discharged day 2 post-operatively (Insert Table 1).

Pre-operatively there were no significant differences in blood levels between any of the groups. CRP levels were significantly higher in the HHRP group on the first ($p = 0.003$) and second post-operative day ($p = 0.004$) (Fig. 7) (Table 2). Surgical time was significantly correlated with CRP-levels at day one ($r = 0.43$; $p = 0.004$) and day two ($r = 0.54$; $p < 0.000$). No significant correlation was found at 1 h post-operatively ($r = 0.22$; $p = 0.15$). ESR-level was significantly higher at day two in the HHRP group ($p = 0.004$) (Fig. 7) (Table 2). No significant difference was found at one and 24 h post-operatively. No significant correlations were found between ESR and the mean surgical time. No significant differences were found for the CK- and LDH-levels at any time post-operatively. The CK and LDH levels were not significantly correlated with the mean surgical time (Insert Table 2 and Fig. 7).

Hb-levels were significantly lower in the HHRP group at day one and day two post-operatively ($p = 0.008$ and $p = 0.03$) (Fig. 7) (Table 2). Hb-levels were negatively correlated with the mean surgical time at day one ($r = -0.30$; $p = 0.049$) and day two ($r = -0.32$; $p = 0.03$). No significant correlation was found at 1 h postoperatively ($r = -0.22$; $p = 0.2$).

Significantly less TFL damage was observed in the ORP and control group compared to the HHRP group ($p = 0,025$) (Table 3). No significant correlations were found between the TFL damage and all the blood levels for CRP, Hb, CK, LDH and ESR (Insert Table 3).

No significant differences were found between the groups for the mean socket inclination ($p = 0.3$) and anteversion ($p = 0.29$). There was no significant difference for the femoral component positioning ($p = 0.68$) (Table 4) (insert Table 4).

The pre- and 6 week post-operative Harris hip scores (HHS) and HOOS-scores were not significantly different between groups (Table 5). There were no intra- or post-operative complications in any of the patients (insert Table 5).

4. Discussion

Minimizing the impact for the patient and the surgical risks during the learning curve of a new technique is one of the most important challenges that our profession is faced with. Every measure that is undertaken to support peer-to-peer training, will allow new surgical techniques to more swiftly get a widespread use. The extent of the learning curve is directly related to the volume of exposure during training.[12,15,16] The inexperience at the beginning of the learning curve leads to prolonged surgical times, which are associated with multiple complications including infection and even mortality following total joint arthroplasty.[17–19] Stable retractor placement is important to minimize muscle damage and to obtain a perfect view for component insertion. Orthostatic retractor placement devices aim to stabilize the retractor with a soft tissue tension under direct control of the surgeon. In addition, the procedure can be conducted with less manpower and mental and physical fatigue is potentially reduced. The Gripper™ Table Mounted System (MedEnvision, Belgium) is comprised of a pulley system that is table mounted on attachable posts. The system provides constant, tireless retraction.[23] The flat-handled retractors are inserted into the Gripper system and once the system is tightened it is a dual pulley system which can be released and tightened as needed. Altogether, the pulley system and retractor form three points of fixation.[23] At our service, we had noted a significant CRP drop in a retrospective analysis of 100 patients operated with the ORP device. We hypothesized that orthostatic retractor placement would also reduce the muscle

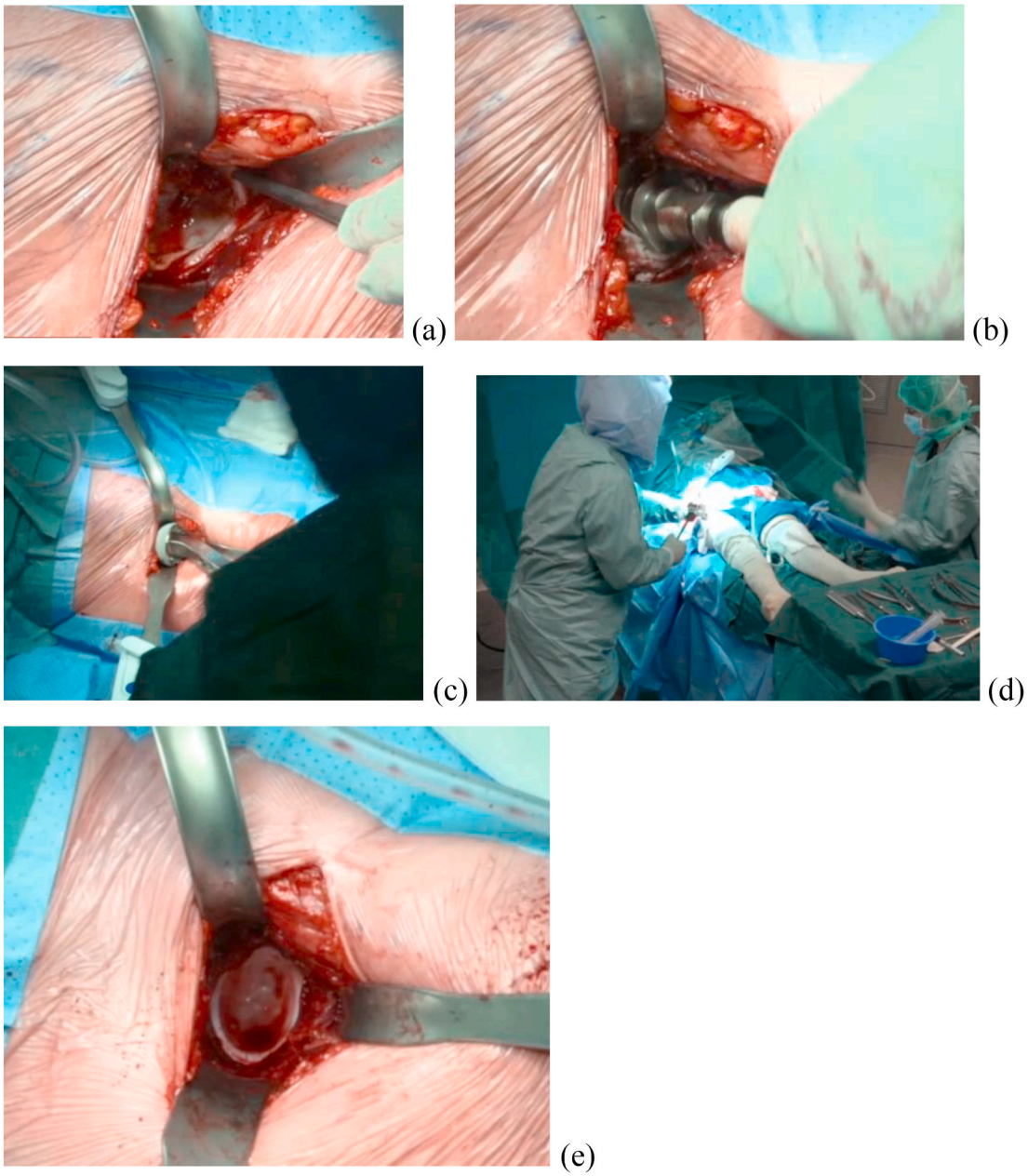

Fig. 5. (a) The transverse acetabular ligament (TAL) is visible after proper retractor placement. Fluoroscopy is not required due to a superb visualisation of the acetabulum and the reaming. (b) Reaming with a straight reamer is done. (c) The socket is inserted. (d) Overview of the OR set-up. (e) The ceramic liner is inserted.

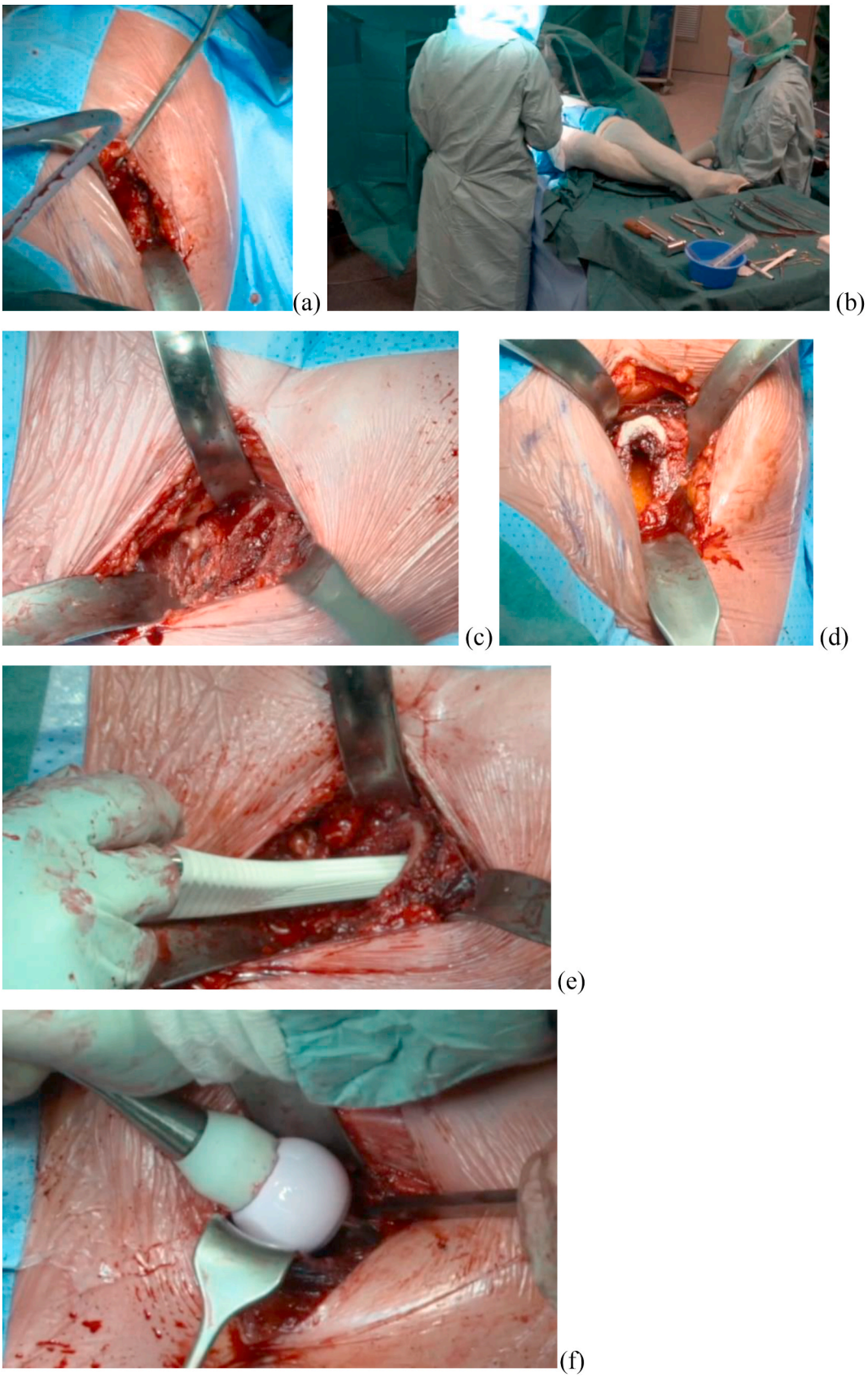

Fig. 6. (a) The bone hook pulls the femur in the lateral direction and the retractor is put at the level of the release. (b) The leg is put underneath the contralateral leg and adducted and externally rotated. (c) Lateral and (d) superior view of the femur. (e) The final stem is inserted. (f) The femoral head is applied.

Table 1
Patient demographics.

		HHRP	ORP	Control ORP expert
Age		61,64 ± 8,35	59,00 ± 7,27	61,21 ± 7,82
Gender	Male	6	7	7
	Female	8	8	7
BMI		29,7 ± 4,85	31,2 ± 3,5	30,1 ± 3,8
ASA-score	1	10	8	9
	2	3	5	4
	3	1	2	1

damage and post-operative inflammatory response during the learning curve of DAA THA.

Both surgeons were in the same stage of their learning curve and had followed the same program, including approximately 10 cases done under the direct supervision of an experienced surgeon. The experienced surgeon was available to interfere and support if deemed necessary. In 15 cases he was requested to provide some advice during the procedure but he did not have to scrub in. Despite the increase in manpower of 2 FTE in the HHRP group, the OR time was by average 20 min longer in

Table 3
TFL damage in the HHRP, ORP trainee and ORP expert groups.

	No damage	Grade 1	Grade 2	Grade 3
	N	N	N	N
HHRP trainee	4	3	5	2
ORP	13	1	1	0
Control ORP expert	10	3	1	0

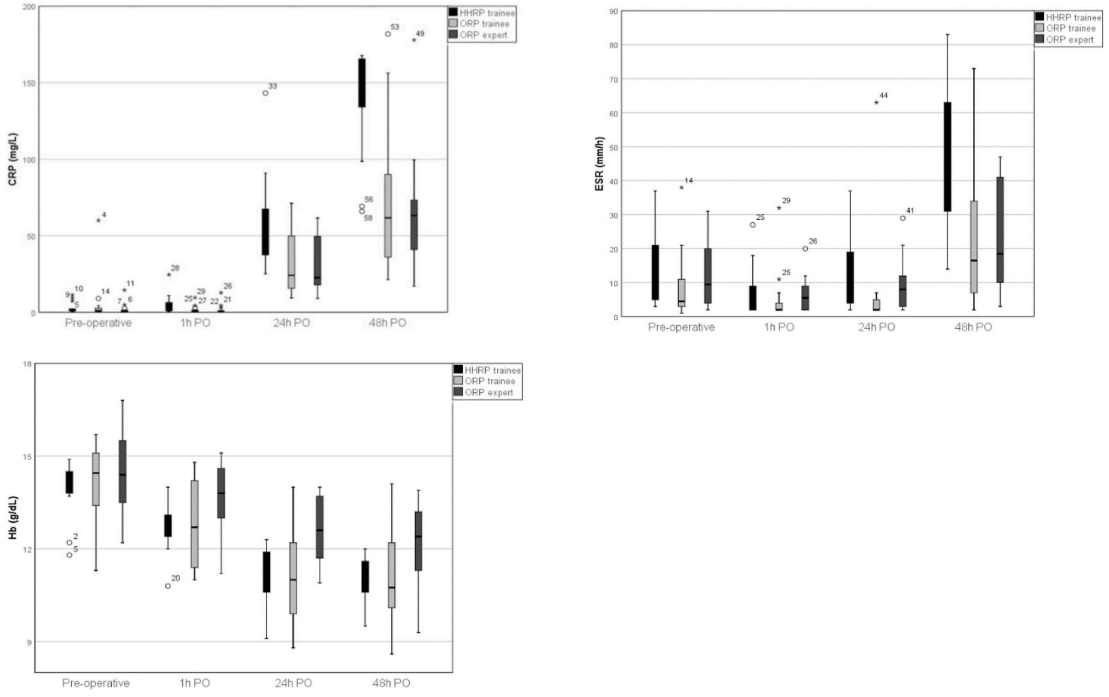

Fig. 7. The CRP, ESR and Hb blood levels.

Table 2
Blood levels of CRP, Hb, ESR, CK and LDH.

		HHRP			ORP			Control ORP expert			P value
		Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	
CRP (mg/L)	Pre-operative	2.89	0.60	11.30	5.94	0.60	60.00	2.18	0.60	14.50	0.298
	1 h PO	4.44	0.60	24.60	1.99	0.60	9.60	2.01	0.60	12.80	0.026
	24 h PO	60.64	25.20	143.20	34.67	9.30	71.20	30.78	9.10	61.60	0.003
	48 h PO	154.54	65.90	369.00	81.60	21.30	219.40	75.38	17.00	234.70	0.004
Hb (g/dL)	Pre-operative	13.14	11.80	14.30	14.17	11.30	15.70	14.54	12.20	16.80	0.700
	1 h PO	12.73	10.80	14.00	12.82	11.00	14.80	13.63	11.20	15.10	0.077
	24 h PO	11.11	9.10	12.30	11.37	8.80	14.00	12.56	10.90	14.00	0.008
	48 h PO	10.86	9.50	12.00	11.25	8.60	14.10	12.20	9.30	13.90	0.030
ESR (mm/h)	Pre-operative	13.21	3.00	37.00	9.40	1.00	38.00	13.21	2.00	31.00	0.198
	1 h PO	7.43	2.00	27.00	5.87	2.00	32.00	6.64	2.00	20.00	0.843
	24 h PO	12.07	2.00	37.00	8.73	2.00	63.00	9.57	2.00	29.00	0.748
	48 h PO	45.21	14.00	83.00	23.73	2.00	73.00	22.79	3.00	47.00	0.004
CK (U/I)	Pre-operative	108.93	41.00	198.00	100.33	0.90	221.00	129.71	36.00	393.00	0.871
	1 h PO	280.07	134.00	445.00	277.19	0.90	708.00	228.57	74.00	427.00	0.254
	24 h PO	726.36	351.00	1324.00	739.49	9.30	2197.00	592.21	204.00	1309.00	0.368
	48 h PO	854.14	406.00	2363.00	1002.65	35.80	2410.00	667.64	256.00	1064.00	0.222
LDH (U/I)	Pre-operative	219.07	146.00	559.00	209.73	150.00	342.00	190.36	139.00	263.00	0.776
	1 h PO	231.64	145.00	488.00	265.87	147.00	761.00	224.21	151.00	422.00	0.871
	24 h PO	188.00	145.00	245.00	211.73	144.00	396.00	210.43	139.00	481.00	0.951
	48 h PO	179.00	146.00	228.00	190.47	151.00	269.00	298.21	123.00	1432.00	0.341

Table 4
Positioning of the acetabular component and femoral component in all the groups.

	HHRP			ORP			Control ORP expert			P value
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	
Inclination acetabular component	31.50	18.45	36.85	34.15	27.80	46.55	30.61	18.55	37.80	0.340
Anteversion acetabular component	15.72	8.10	18.30	14.96	11.90	18.40	15.74	5.70	20.40	0.290
Varus positioning femoral component	1.31	0.20	3.70	1.69	0.60	4.65	1.54	0.15	5.45	0.680

Table 5
Harris Hip Scores (HHS) and Hip disability and Osteoarthritis Outcome Scores (HOOS).

		HHRP							
		Preoperative		Six weeks		Three months		Six months	
		Mean	σ	Mean	σ	Mean	σ	Mean	σ
HHS		45.60	12.50	63.22	14.01	74.83	12.35	74.71	17.32
Hoos	ADL	35.20	18.57	76.00	17.79	82.83	15.64	88.57	10.31
	Pain	32.90	16.68	72.11	19.13	81.50	11.61	85.29	13.76
	QOL	21.90	16.39	66.11	16.80	65.67	16.31	69.00	20.36
	Sports	16.80	23.77	54.22	20.93	58.50	32.82	58.00	40.12
	Symptoms	33.00	16.19	72.78	17.16	78.33	7.53	81.43	22.49
		ORP							
		Preoperative		Six weeks		Three months		Six months	
		Mean	σ	Mean	σ	Mean	σ	Mean	σ
HHS		53.05	17.04	57.13	14.59	80.80	5.36	83.00	4.85
Hoos	ADL	47.67	21.05	75.50	13.13	89.80	9.42	88.40	11.41
	Pain	38.83	17.78	72.81	17.23	89.80	8.01	88.60	13.69
	QOL	31.22	14.24	55.69	14.36	77.60	14.21	82.60	11.24
	Sports	21.89	21.46	40.19	22.96	60.00	18.63	68.80	14.50
	Symptoms	41.67	20.31	65.00	11.65	83.00	10.37	89.00	11.40
		Control ORP expert							
		Preoperative		Six weeks		Three months		Six months	
		Mean	σ	Mean	σ	Mean	σ	Mean	σ
HHS		51.00	14.57	60.64	17.50	74.57	13.67	74.75	18.01
Hoos	ADL	52.80	17.85	76.45	18.48	85.00	12.22	79.13	25.61
	Pain	43.30	15.09	76.64	21.20	81.86	14.80	78.25	25.73
	QOL	34.40	14.87	63.27	19.79	72.43	24.68	72.00	26.89
	Sports	27.10	20.30	56.36	28.59	56.43	24.26	54.88	31.16
	Symptoms	42.50	20.45	71.82	20.77	77.14	18.45	74.38	25.97
		P values							
		Preoperative		Six weeks		Three months		Six months	
HHS		0.522		0.639		0.661		0.906	
Hoos	ADL	0.137		0.883		0.774		0.880	
	Pain	0.385		0.861		0.558		0.885	
	QOL	0.240		0.509		0.330		0.565	
	Sports	0.325		0.440		0.929		0.797	
	Symptoms	0.460		0.396		0.784		0.633	

comparison to the ORP cases where only the surgeon and the scrub nurse were scrubbed in. CK and LDH levels were not significantly lower in the HHRP group. However, significantly more TFL damage was noted and the post-operative inflammatory response as indicated by CRP and ESR levels was also significantly higher. The increased inflammatory response was significantly correlated with the prolonged OR times in the HHRP group. Similarly, lower post-operative Hb-levels were also significantly correlated with longer OR times. During the learning curve, the use of an ORP device allowed for a reduction in OR time, TFL damage, post-operative inflammatory response and blood loss.

Not unexpectedly, the mean OR time during the learning curve is longer compared to an experienced surgeon.[16] In our series, the learning curve ORP OR time was 13 min longer than the experienced control cohort. Interestingly, this did not result in a significant reduction in post-operative CRP-, ESR- or HB-levels. In addition, although the procedure was conducted with less manpower than in the HHRP group, this did not result in different component positioning. We acknowledge that the mean socket inclination and anteversion of 32° and 15°, respectively, can be considered as low.[13,21] However, our aim is to use an anteversion angle parallel to the transverse acetabular ligament and to have a socket inclination angle between 30 and 35° to maximize implant stability. In a recent study of 617 THA conducted at our institution, there was a dislocation rate of 0,3%.[24] Finally, we also showed that the PROMs were not influenced by the learning curve.

There are some shortcomings to this study. The 'learning curve' is very difficult to define and surgeon dependent. The procedures were conducted in a well-established OR environment with trained nurses, which might be different from an environment where the OR staffing is less familiar with the new procedure. However, this allowed us to isolated retractor placement as the sole different variable between the cohorts. For the safety of the patient, the experienced surgeon was present. He did not physically and directly interfere with the procedure. This could have influenced the surgical time but for the safety of the patients it was deemed necessary from a deontological point of view. Finally, Only one ORP device was used and therefore the results of our study might not be applicable to other kinds of ORP devices.

5. Conclusion

Orthostatic retractor placement can be an adjunct to minimize the impact of the learning curve during anterior approach THA. Standardized retractor placement significantly reduced OR times, post-operative inflammatory response and blood loss.

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