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The Effect of Drainage After Hip Arthroplasty

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1. Introduction

Closed suction drainage is a routinely used method in all fields of surgery. The idea to drain a wound is quite old. Supposedly, Hippocrates had already used a wooden tube to drain the operative wound (Levy, 1984). In orthopaedic surgery, Waugh and Stinchfield were the first who popularized the method of draining. Their preference to draining was based on their retrospective study, where they observed the incidence of wound infection after various orthopaedic procedures (Waugh & Stinchfield, 1961). The group of 100 patients with closed suction drainage was compared with a similar group (identical procedure, same comorbidities and the same surgeon) of 100 patients without the drainage. Wound infection occurred in 1% of patients with closed suction drainage and in 3% of patients without the drainage. They also noted that the post-operative rehabilitation was quicker if they drained the operated joint after an arthroplasty. Even though the difference in incidence of wound infection was not statistically significant, they concluded that a more benign postoperative course can be expected if the drains are used.

After that, the use of drains quickly spread in all areas of orthopaedic surgery. It seemed logical to drain the operative wound. Exposed intramedullary canal and trabecular bone make it difficult to create a perfect hemostasis. A hematoma inevitably forms which increases the pressure on the surrounding tissues. Increased pressure impairs blood flow and healing of the operative wound. Additionally, a hematoma is also a good culture medium for bacteria (Cheung et al., 2008; Parvizi et al., 2007). The function of phagocytic cells to eliminate these bacteria in hematoma is weakened. The first reason for this weakened elimination is that phagocytic cells have a hardened access to the bacteria in the hematoma. Secondly, due to the low level of opsonic proteins in hematoma, the destruction capacity of phagocytic cells is damaged (Alexander et al., 1976). Therefore, in order to prevent the infection of the surgical wound, it appears logical to drain the wound to avoid or at least reduce the formation of hematoma.

New studies have emerged at the end of the 20th century. These studies have questioned the logical mechanism of drainage and the use of drainage in hip arthroplasty. There are several potential adverse effects from draining. Drain tubes may become contaminated and allow a retrograde migration of the skin bacteria around the wound. In addition, drains may be inadvertently sutured to surrounding tissues and are difficult to remove post-operatively. Furthermore, drains may increase the amount of blood loss and increase the need for

transfusion. The findings from these new studies have convinced many surgeons to change their routine and re-think the need for drainage in total hip arthroplasty.

2. Literature search methods

All randomized controlled trials that compared closed suction drainage to no-drainage after elective hip arthroplasty were searched. Additionally, studies that could provide further information on relevant aspects of drainage (eg. relative amount of drainage in the first 24 hours, hematoma size estimation using one or two drain tubes, bacterial growth on suction drain tips, etc.) were included. Trials involving other than elective hip arthroplasty (arthroplasty for fracture treatment) were excluded. The following search terms were used in Pubmed database: "drainage hip arthroplasty", "drains hip arthroplasty", "serous drainage hip arthroplasty". Two authors independently examined all articles that were obtained with this search strategy. Articles were assessed for relevance and handpicked. Differences between authors were resolved by discussion.

The selection procedure resulted in 6 studies directly comparing the use of closed suction drainage to un-drained wound closure (Murphy & Scott, 1993; Kim et al., 1998; Widman et al., 2002; Della Valle et al., 2004; Johansson et al., 2005; Walmsley et al., 2005). The basic information about the studies is depicted in Table 1.

Study	Drained group (hips, n)	Un-drained group (hips, n)	Number of drains (n)	Time of drain removal (h)	Follow-up
Murphy & Scott, 1993	20	20	2	24	10 days
Kim et al., 1998	48	48	2	24	1 year
Widman et al., 2002	10	12	2	24	NA*
Della Valle et al., 2004	53	51	2	next morning	3 months
Johansson et al., 2005	54	51	NA	NA	2 months
Walmsley et al., 2005	282	295	1	24	3 years

* data not available

Table 1. Studies with a direct comparison of drained group to un-drained group.

Seven studies, which in addition to groups with and without closed suction drainage after hip arthroplasty, compared groups with different interventions (eg. additional group after knee arthroplasty; two drained groups, one with 24-hour drainage, the other with 48-hour drainage; two drained groups, one with autologous blood transfusion drain, one with conventional closed suction drainage) were also included in a review (Beer et al., 1991; Ritter et al., 1994; Ovadia et al., 1997; Niskanen et al., 2000; Kumar et al., 2007; Strahovnik et al., 2010; Cheung et al., 2010). Characteristics of those studies are presented in Table 2.

Three more studies were included with relevant data on infection of the surgical wound, one study with data on hematoma size and two studies on the prolonged serous secretion

from the surgical wound (Willett et al., 1988; Sørensen & Sørensen, 1991; Overgaard et al., 1993; Parrini et al., 1988; Wood et al., 2007; Patel et al., 2007).

Study	Drained group (hips, n)	Un-drained group (hips, n)	Additional intervention - arm
Beer et al., 1991	12	12	two knee groups
Ritter et al., 1994	78	62	two knee groups
Ovadia et al., 1997	18	12	two knee groups
Niskanen et al., 2000	27	31	two knee groups
Kumar et al., 2007	19	15	two knee groups
Strahovnik et al., 2010	46	42	group with 48h drainage
Cheung et al., 2010	52	48	group with autologous transfusion drain

Table 2. Studies with additional research arm(s).

Different aspects of wound healing with or without drainage after hip arthroplasty were reviewed and compared among the selected studies. The effectiveness of drainage with regard to those aspects is discussed under the following heading. Drainage also has an unwanted side effect that was not present in the un-drained groups, which is reported in a later heading as a complication.

3. Effectiveness of drainage in total hip arthroplasty

The impact of drainage on the bacterial growth and wound infection was regarded as the most important outcome. The drainage influence on the size of hematoma, the healing of the surgical wound, the need for transfusion and hospital stay were also reported in most of the studies.

3.1 Bacterial growth and wound infection

No significant difference in the occurrence of wound infection was found in the studies that were directly comparing patients whose wounds were drained and patients with un-drained wounds. If infection was present, it was regarded as superficial in the majority of cases. Deep wound infection was very rare or none. Results are summarized in Table 3.

Other studies that were comparing groups with additional intervention, as well as drainage and no-drainage groups after hip arthroplasty, also could not show any differences in wound infection.

Altogether, there were 30 out of 719 patients with wound infection (superficial and deep) in the drained groups, and 27 out of 699 patients in the no-drained groups (relative risk 1.08; 95% confidence interval 0.65 - 1.80).

Wound infection is a serious complication after elective hip arthroplasty. It should be regarded as the most important reported outcome. The problem is that the occurrence of wound infection, either superficial or deep, is very low. In order to achieve the required power and still get a clinically significant difference between groups, a large number of patients would need to be included in a study. In a hypothetical scenario, where we would have, for example, a 6% incidence of wound infection in the drained group, and a 3% incidence in the no-drained group (no published study reported such a big difference), and

the power of a study 0.8, we would need at least 312 patients to achieve a significant difference with probability less than 0.05.

The only single study that included a sufficient number of patients was from Walmsley et al. They found the rate of superficial infection 2.9% in the drained group and 4.8% in the un-drained group. The rate of deep wound infection was 0.4% in the drained group and 0.7% in the un-drained group. The differences in the incidence of wound infection were not statistically significant. The only existent meta-analysis on hip arthroplasty managed to pool 711 patients with drained wounds and 704 patients with un-drained wounds (Parker et al., 2008). The pooled results indicated that there was no significant difference between the wounds treated with a drain and those treated without a drain with respect to the occurrence of wound infection.

Study	Wound infection - deep&superficial (n/N)		Deep wound infection (n)	
	Drained group	Un-drained group	Drained group	Un-drained group
Beer et al., 1991	0/12	0/12	0	0
Murphy & Scott, 1993	1/20	0/20	NA	NA
Ritter et al., 1994	0/78	0/62	0	0
Ovadia et al., 1997	0/18	0/12	0	0
Kim et al., 1998	0/48	0/48	NA	NA
Niskanen et al., 2000	1/27	1/31	0	0
Widman et al., 2002	1/10	1/12	1	1
Della Valle et al., 2004	2/53	0/51	0	0
Johansson et al., 2005	3/54	2/51	0	0
Walmsley et al., 2005	19/282	23/295	1	2
Kumar et al., 2007	0/19	0/15	0	0
Strahovnik et al., 2010	1/46	0/42	0	0
Cheung et al., 2010	2/52	0/48	0	0

Table 3. Incidence of wound infection.

Another problem with reporting incidence of wound infection is limited follow-up. Many studies followed patients only until first clinical control. This may have resulted in an underreporting of not only the infection rate but of several other outcomes as well (eg. re-operation rate).

We can conclude that drainage does not have a clinically relevant effect on wound infection after hip arthroplasty.

3.1.1 Connection between wound infection and duration of drainage

The supposedly beneficial effect of drainage on the bacterial growth in the drained hematoma was actually one of the first assumptions to become questioned. Willett et al. performed a study with 120 patients after hip arthroplasty (Willett et al., 1988). They implied a connection between wound infection and the duration of drainage. Even though the correlation did not reach the statistical significance, the authors recommended removal of drains 24 hours after the operation. Drainage after 24 hours did not reduce the size of hematoma, but it did increase the chance of bacterial infection.

Similarly, Sørensen and Sørensen also investigated the relation between bacterial growth and duration of drainage (Sørensen & Sørensen, 1991). They prospectively followed 489 patients after various orthopaedic operations. They showed that signs of wound infection and drain tip cultures were significantly more often positive, if the drainage lasted more than 6 days. The explanation they offered was that the drain allows the bacteria on the skin around the wound to retrogradely migrate.

On the other hand, another study between drain tip cultures and the duration of drainage did not show any statistically significant correlation (Overgaard et al., 1993). The authors commented that this unexpected lack of correlation might be explained with a relatively short duration of drainage in their study (maximum 3 days). They also noticed that most of the drainage occurred within first 12 hours, and hence also recommended to remove the drains rather sooner than later.

Additional studies on relationship between the duration of drainage and bacterial infection were performed (Drinkwater & Neil, 1995; Erceg & Becić K, 2008; Rowe et al., 1993). A general consensus was gradually formed that the optimal time to remove the drains in hip arthroplasty would be 24 hours after the operation. Drainage after first 24 hours does not evacuate significant amount of blood and only increases the chance of bacterial retrograde migration.

3.2 Hematoma size

Several studies evaluated the size of hematoma after hip arthroplasty (Murphy & Scott, 1993; Kim et al., 1998; Widman et al., 2002). Hematoma size can be evaluated using different methods, but none of them is very accurate. Most of the studies used a formula which uses pre-operative and post-operative hematocrit values to calculate hidden blood loss (hematoma). In some studies an ultrasound examination of the thigh was used, in order to measure the thickness of blood mantle around the prosthesis. Other methods have also been used, such as a scintigraphy with labeled erythrocytes or a simple tape measurement of the thigh circumference.

In one study a calculated hidden loss in the wound was compared between a group with drainage and a group without the drainage (Murphy & Scott, 1993). Hematoma in the drained group was not smaller. The authors explained this unexpected result with a tamponade effect mechanism. The tamponade effect refers to the fact that the bleeding in the wound continues until the pressure in the wound increases. In order to achieve the critical pressure, enough bleeding must occur to fill out the space (dead space) around the prosthesis. Since the tissues around the hip prosthesis are relatively rigid and immobile, the suction from the drain does not reduce the space around prosthesis (dead space). In other words, regardless the wound is drained or not, enough bleeding into the wound must occur to create the tamponade effect. Furthermore, a drain enlarges the dead space for the amount of space of a drain tube and a drain device. Therefore, even more blood must be lost to achieve the tamponade effect, if a drain is used. Paradoxically, drains therefore increase the blood loss after the operation.

Widman et al. used a more objective method of determining the hematoma size (Widman et al., 2002). They used a scintigraphy with labeled erythrocytes to compare a group of patients with two-drain drainage to a group of patients without the drainage. The hematoma size was quantitatively measured using SPECT (single photon emission computed tomography). Even though a smaller hematoma was found when two drains were used, the difference

between patients with drained wounds and patients with un-drained wounds was not statistically significant. Patients with drainage also lost more blood and more often required blood transfusion in the postoperative period. The authors' interpretation was consistent with a tamponade effect theory.

On the other hand, Kim et al. routinely used ultrasound to assess the size of wound hematoma on the sixth or seventh day after the surgery (Kim et al., 1998). The wound hematoma was classified as none, small or large, according to the thickness of the hypoechoic density along the region of the wound. Thirteen drained wounds (27.1%) and 26 non-drained wounds (54.2%) had large hematomas; large hematomas were significantly more often present in patients without the drainage. In addition, 13 wounds with closed suction drainage (27.1%) and 4 wounds without the drainage (8.3%) did not have hematomas, which was also statistically significant difference. The possible explanation the authors offered was that the use of suction drains may not evacuate hematomas completely in the hip joint, and that small hematomas re-accumulate in the hip joint after the drain is removed.

Another study examined the hematoma size using an ultra-sonographic evaluation (Parrini et al., 1988). Within 82 patients after total hip arthroplasty, a comparison between patients with two drains and patients with one drain was made. A hematoma in the wound was always present, regardless to the number of drains. However, the authors did find the hematoma to be significantly smaller in patients, where two drains were used instead of one.

We also performed a study where we compared 3 groups: a group without drainage, a group with 24-hour drainage and a group with 48-hour drainage. A semi-quantitative estimation of the wound hematoma size was performed with measurements of the operated thigh circumference. Measurements of the thigh circumference were routinely performed before and after elective total hip arthroplasty. In the un-drained group, the change of thigh circumference significantly increased in the post-operative period, when compared with the change in both drained groups. Most of the increase of thigh circumference occurred within first 48 hours after the procedure. Our results were consistent with findings of both previous studies. The use of drainage slightly decreases hematoma size in the post-operative period. However, the drains do not evacuate hematomas completely, and hematomas re-accumulate to a certain extent after the drains are removed.

3.3 Healing of the surgical wound

There are few studies thoroughly describing wound healing parameters, such as bruising of the wound area and persistent drainage from the wound. No study reported any serious healing complications (eg. necrosis of the skin around the wound). Most of the studies described healing as uneventful in either drained or un-drained groups and did not notice any difference.

3.3.1 Bruising of the wound area

There is only one study reporting bruising around the wound area after hip arthroplasty. Kim et al. measured the area of bluish discoloration around the wound site. The ecchymosis was present in 11 hips from the un-drained group, as opposed to 3 hips from the drained group ($p < 0.05$). They recommended the routine use of suction drains after primary total hip arthroplasty to reduce ecchymosis around the wound. Other studies did not specifically report the bruising around the wound area.

3.3.2 Persistent drainage from the wound site

There are two types of prolonged drainage in hip arthroplasty. The first type occurs in the surgical wound and can happen whether the wound is drained or not. The second type of drainage occurs only in drained wounds, at the drain site after the drain is removed.

The drainage from the surgical wound usually starts on the first post-operative day and rarely lasts for more than a couple of days. The drainage is usually bloody. This type of drainage is more frequent if the wound is not drained. Kim et al. found persistent drainage from the surgical wound in 3 of 48 wounds with suction drains and 11 of 48 wounds without suction drains. Other studies do not specifically report the drainage from the wound site.

Sometimes a later secretion from the surgical wound develops which is serous in nature and may last longer. This type of serous secretion has been linked to the development of superficial surgical site infection and deep wound infection (Saleh et al., 2002). Serous secretion allows an open communication between the deep layers of the surgical wound and the skin. The longer this communication exists, the more chance there is for migration of bacteria from the skin.

Two studies have analyzed risk factors that predispose to the longer duration of prolonged serous secretion from the wound site. Wood et al. associated time to dryness of the surgical wound with: wound length, body mass index (BMI) and estimated volume of blood in the dissected tissues (Wood et al., 2007). Patel et al. found that prolonged wound drainage correlated with: morbid obesity (BMI $\geq 40\text{kg/m}^2$), increased volume of drain output and use of low-molecular-weight heparin (Patel et al., 2007). In both studies, the length of hospital stay was significantly increased in patients with prolonged drainage. Patel et al. also stated that each day of prolonged wound drainage increased the risk of wound infection by 42% following a total hip arthroplasty.

3.3.3 Re-operation for wound healing complication

There was no statistically significant difference in the re-operation rate between the groups (Table 4).

Study	Drained group (n/N)	Un-drained group (n/N)
Kim et al., 1998	0/48	0/48
Della Valle et al., 2004	1/53	0/51
Johansson et al., 2005	0/54	0/51
Walmsley et al., 2005	1/282	0/295
Strahovnik et al., 2010	1/46	0/42
Cheung et al., 2010	0/52	0/48

Table 4. Re-operation due to wound healing complications.

3.4 Post-operative range of hip motion

There was only one study numerically reporting post-operative range of motion. Kim et al. reported no extension lag in either group at the 2-month follow-up. Mean flexion reached 90° in the drained group and 95° in the group without drainage.

3.4.1 Need for re-enforcement of the dressing

Since more patients without closed suction drainage have a persistent drainage from the surgical wound, more wounds need to be re-enforced in the early post-operative period.

Several studies have reported a greater need for re-enforcement of the dressing in the un-drained groups (Table 5). Two of them have found a statistically significant difference between drained and un-drained groups (Kim et al. 1998; Strahovnik et al., 2010).

Study	Drained group (n/N)	Un-drained group (n/N)
Kim et al., 1998	3/48	11/48
Niskanen et al., 2000	1/27	4/31
Della Valle et al., 2004	6/53	10/ 51
Strahovnik et al., 2010	2/46	20/42

Table 5. Studies with reported need for re-enforcement of the dressing.

3.5 Need for blood transfusion

The majority of included studies evaluated the need for transfusion. The need for transfusion is an easily measured parameter and could be one of the most important evidences of the tamponade effect theory. One point needs to be addressed with regard to the transfusion needs as an outcome measure. Different transfusion triggers were used in analyzed studies. Some authors used an absolute hemoglobin cutoff point, with values bellow that point necessitating a blood transfusion. Others used various recommended algorithms or they simply treated each patient and their requirements for allogeneic blood on an individual basis. In some studies the transfusion algorithm was not well described. This heterogeneity of transfusion policies could not be eliminated in the analysis. Different transfusion triggers among and even within the studies reduce the reliability of the need for transfusion as an outcome measure.

There is a trend in the need for more blood transfusion if drains are used in total hip arthroplasty. Many studies showed the increased need for transfusion in patients with drained wounds but only studies by Walmsley et al., Strahovnik et al. and Cheung et al. showed that the need for transfusion was significantly more often required in patients with drainage (Table 6).

Study	Patients transfused		p
	Drained group (n/N)	Un-drained group (n/N)	
Ovadia et al., 1997	9/18	2/12	0.06
Widman et al., 2002	9/10	6/12	0.07
Della Valle et al. 2004	21/53	18/51	0.7
Johansson et al. 2005	36/54	28/51	0.3
Walmsley et al., 2005	93/282	78/295	0.042
Kumar et al., 2007	13/19	10/15	0.13
Strahovnik et al., 2010	22/46	30/42	0.024
Cheung et al., 2010	19/52	6/48	0.02

Table 6. Incidence of transfusion needed in drained and un-drained groups.

For included studies in Table 6, the relative risk for transfusion in patients with closed suction drainage opposed to patients without drainage was 1.23 (95% confidence interval 1.05 – 1.44). Accordingly, more units of red cell concentrates were given to patients in the drained groups (Table 7). However, when there was a need for blood transfusion, patients received

approximately the same amount of red cell concentrates, regardless of the fact whether the wound was drained or not.

Study	Units of blood given (n)/number of patients)	
	Drained group	Un-drained group
Ovadia et al., 1997	13U/9	3U/2
Johanson et al., 2005	110U/36	69U/28
Cheung et al., 2010	36U/19	11U/6

Table 7. Number of units of red cell concentrates given.

Results are consistent with the tamponade effect theory. Drains evacuate the blood that would otherwise be required to achieve the sufficient intra-wound pressure in order to stop the bleeding. The more blood is evacuated, the greater the need for transfusion.

3.6 Hospital stay

With the exception of studies by Cheung et al. and Della Valle et al., which reported a significant difference between the drained and un-drained group, other studies did not find any differences in hospital stay after hip arthroplasty. Drainage does not seem to directly affect the duration of hospitalization. Mean values of hospital stay ranged from 5 to 10 days in both of groups (Table 8). Within the two studies with statistically significant difference in hospital stay, only the difference of one day could be regarded as clinically relevant. Authors interpreted that this difference in length of stay is most likely a reflection of the greater amount of time it took for the drained wounds to become dry. However, wound-healing disturbances in the drained group might have been related to an allogeneic transfusion (in this particular study, the transfusion rates were much higher in patients with closed suction drainage), and not to drain usage per se.

Study	Drained group (days)	Un-drained group (days)	p
Ovadia et al., 1997	10	8.3	0.06
Della Valle et al., 2004	5.1	4.7	0.01
Walmsley et al., 2005	10	10	NA
Kumar et al., 2007	8.9	8.4	0.32
Strahovnik et al., 2010	7	7	0.55
Cheung et al., 2010	7	6	0.03

Table 8. Average hospitalization time.

Namely, there seems to be a relation between allogeneic transfusion and disturbances in wound healing, which in turn affects the hospital stay. The mechanism by which wound-healing disturbances and length of hospital stay are related are still unclear (Weber et al., 2005). First possible explanation is a direct effect of tissue hypoxia as a consequence of decreased values of hemoglobin in the post-operative period. However, in a clinical study, the anemia was present in groups without closed suction drains as well and did not affect wound healing. This effect seems, therefore, unlikely. The alternative explanation might be the immuno-modulatory effect of allogeneic blood. Experimental studies have shown that the immuno-modulatory effects of allogeneic blood transfusion might lead to a decrease in proangiogenic factors that are essential

for wound healing (eg. interleukin 8). Allogeneic blood transfusion might therefore induce a small but significant delay in wound healing. Since drainage seems to affect the transfusion rates, it might also indirectly influence the hospital stay.

3.7 Cost analysis

Three studies analyzed the costs of drainage in total hip arthroplasty. The savings of the cost of closed suction units (hemovac) was reported if drains were omitted in hip arthroplasty (Ritter et al., 1994; Kim et al., 1998). Della Valle et al. stated that the additional sum could be saved due to a shorter hospital stay in patients without closed suction drainage.

4. Complications of drainage

The unwanted side effects, which occur only in patients where closed suction drainage was used, are described here. The possible deleterious effects of drains on wound infection, need for transfusion and hospital stay were already discussed in the previous section.

4.1 Prolonged drainage from the drain site

Prolonged drainage from the wound is the second type of prolonged drainage in hip arthroplasty. This type of persistent, prolonged drainage occurs on the drain site after the drain is removed. It is more frequent (up to 50% of patients with drainage) and usually more persistent.

Our own study showed that prolonged secretion from the drain site typically started on the third post-operative day and lasted for four days on the average. Prolonged secretion rarely lasted more than 14 days. In addition, the incidence and duration of prolonged serous secretion were comparable between the group with 24-hour drainage and the group with 48-hour drainage. The greatest proportion of patients with active secretion in both groups was present on the 5th post-operative day (Figure 1).

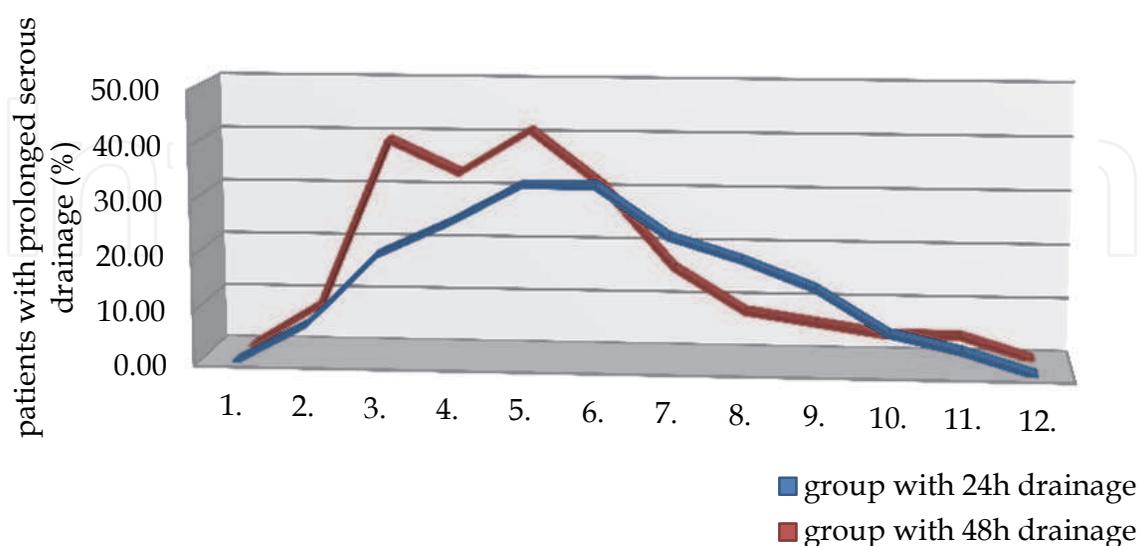


Fig. 1. Proportion of patients with active secretion from the drain site in groups with drainage.

Division of prolonged drainage on the drainage from the wound site and the drainage from the drain site is arbitrary. The cause of drainage is the same regardless on the location. The drainage is linked to a hematoma that develops around the prosthesis. At first, the drainage is bloody, but later turns to serous fluid as the red cells in hematoma sediment. Since the hematoma in the wound is always present whether the drain is present or not, prolonged drainage is always possible. In the un-drained wounds, the drainage can occur through the incision plane, especially if the fascia was not meticulously sutured. In case of a drained wound, the hematoma drains through the drain tube. After the drains are removed, the hematoma may drain through the un-healed drain canal (Figure 2). The drainage stops with the healing of the canal.



Fig. 2. Wound with prolonged serous secretion through an un-healed drain canal.

In conclusion, late secretion from the drain site is frequent and usually spontaneously resolves within 3 to 4 days. Longer secretion, especially longer than 14 days, predisposes to the development of wound infection. Careful observation, supervised regular changing of the dressings and even revision surgery may be necessary to stop the secretion in persistent cases.

5. Additional methods to influence the drainage

Several additional methods can be applied to decrease the bleeding and hence drainage from the surgical wound. The use of hypotensive anesthesia is well established in orthopaedic surgery. A thorough hemostasis at the end of the procedure is also a prerequisite in hip arthroplasty. Some advocate the use of pneumatic wound compression as a method of reducing post-operative bleeding.

Recently, pharmacological strategies have become of interest to decrease excessive blood lost. An intravenous administration of tranexamic acid before hip arthroplasty significantly decreased peri-operative bleeding (Ekbäck et al., 2000; Singh et al., 2010). Tranexamic acid seems to be a cost-effective and safe mean of minimizing blood loss and reduction in

hemoglobin concentrations as well as the need for allogeneic blood transfusion, without increasing the risk of thromboembolic events.

6. Conclusion

Common practice of draining has recently become questioned in orthopaedic surgery. Many randomized trials have been performed, trying to provide a definite answer about the efficacy of draining. Even though the number of trials on the topic is considerable, very few have good methodology which would allow us to draw reliable conclusions. The majority of studies were underpowered for accurate assessment of most important outcomes (eg. wound infection, re-operation rate). Many of them also had a short follow-up period, which allows underreporting of important medical events.

Having already realized the drawbacks of studies in the literature, Parker et al. carried out a meta-analysis. However, due to enormous variety of methods in the orthopaedic community, it is very hard to find studies with homogeneous group of patients. The common denominator of selected studies in their meta-analysis as well as in this review was an elective total hip arthroplasty. Numerous other parameters that could affect the outcomes could not be controlled. For example, even though patients underwent the same procedure, the surgical approach was not uniform in the included studies. Patients varied also in several other parameters: diagnosis, number of drains placed, location of drains, duration of drainage, type of prosthesis, use of thromboprophylaxis, compression of the thigh, trigger for transfusion, post-operative rehabilitation regime, patient's discharge trigger and follow-up period. All these parameters were not uniform or were not even reported.

An evaluation of most of the reported outcomes was given in our review. Since a simple division into pro draining and con draining could not be made for the majority of the observed outcomes, we summarized our conclusions about outcomes as a degree of certainty with regard to the evidence available. Our conclusions are presented in Table 9.

outcome	in favor of		draining	in disfavor of	
	definite evidence	some evidence	undecided	some evidence	definite evidence
Wound infection			X		
Hematoma formation			X		
Bruising of the wound		X			
Drainage from wound		X			
Re-operation			X		
Rehabilitation			X		
Need for re-enforcement		X			
Need for transfusion				X	
Hospital stay				X	
Cost					X
Drainage from drain site					X

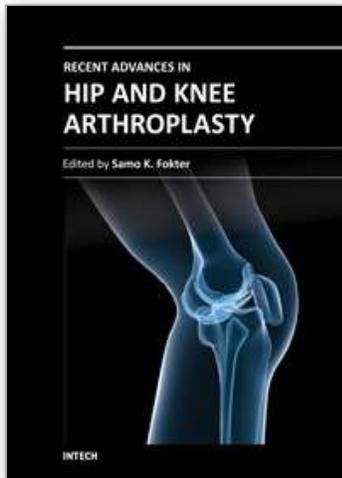
Table 9. List of outcomes and categorization in terms of pro et contra draining.

In conclusion, randomized studies have shown that closed suction drainage is not necessary in total hip arthroplasty and may be, in some aspects, even deleterious. However, due to the heterogeneity of practice, every surgeon must combine his own routine with the decision to drain.

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The purpose of this book is to offer an exhaustive overview of the recent insights into the state-of-the-art in most performed arthroplasties of large joints of lower extremities. The treatment options in degenerative joint disease have evolved very quickly. Many surgical procedures are quite different today than they were only five years ago. In an effort to be comprehensive, this book addresses hip arthroplasty with special emphasis on evolving minimally invasive surgical techniques. Some challenging topics in hip arthroplasty are covered in an additional section. Particular attention is given to different designs of knee endoprotheses and soft tissue balance. Special situations in knee arthroplasty are covered in a special section. Recent advances in computer technology created the possibility for the routine use of navigation in knee arthroplasty and this remarkable success is covered in depth as well. Each chapter includes current philosophies, techniques, and an extensive review of the literature.

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