

Research Paper

# Managing persistent wound leakage after total knee and hip arthroplasty. Results of a nationwide survey among Dutch orthopaedic surgeons

Frank-Christiaan Wagenaar\*<sup>1</sup>✉, Claudia A.M. Löwik\*<sup>2</sup>, Martin Stevens<sup>2</sup>, Sjoerd K. Bulstra<sup>2</sup>, Yvette Pronk<sup>3</sup>, Inge van den Akker-Scheek<sup>2</sup>, Marjan Wouthuyzen-Bakker<sup>4</sup>, Rob G.H.H. Nelissen<sup>5</sup>, Rudolf W. Poolman<sup>6</sup>, Walter van der Weegen<sup>7</sup>, Paul C. Jutte<sup>2</sup>, on behalf of the LEAK study group

1. Department of Orthopaedics, OCON, Center for Orthopaedic Surgery, Hengelo, The Netherlands
2. Department of Orthopaedics, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands
3. Research Department, Kliniek Viasana, Mill, The Netherlands
4. Department of Medical Microbiology and Infection Prevention, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands
5. Department of Orthopaedics, Leiden University Medical Center, Leiden, The Netherlands
6. Department of Orthopaedics, Onze Lieve Vrouwe Gasthuis, Amsterdam, The Netherlands
7. Department of Orthopaedics, Sint Anna Ziekenhuis, Geldrop, The Netherlands

\* Frank-Christiaan B.M. Wagenaar and Claudia A.M. Löwik share a joined first authorship.

✉ Corresponding author: Frank-Christiaan Wagenaar; OCON, Geerdinksweg 141, 7555 DL Hengelo, The Netherlands. Tel: +031 (0)887085328; Fax: +031 (0)887083752; E-mail: f.wagenaar@ocon.nl

© Ivyspring International Publisher. This is an open access article distributed under the terms of the Creative Commons Attribution (CC BY-NC) license (<https://creativecommons.org/licenses/by-nc/4.0/>). See <http://ivyspring.com/terms> for full terms and conditions.

Received: 2017.08.11; Accepted: 2017.09.24; Published: 2017.11.03

## Abstract

**Background:** Persistent wound leakage after joint arthroplasty is a scantily investigated topic, despite the claimed relation with a higher risk of periprosthetic joint infection. This results in a lack of evidence-based clinical guidelines for the diagnosis and treatment of persistent wound leakage after joint arthroplasty. Without such guideline, clinical practice in orthopaedic hospitals varies widely. In preparation of a nationwide multicenter randomized controlled trial on the optimal treatment of persistent wound leakage, we evaluated current Dutch orthopaedic care for persistent wound leakage after joint arthroplasty.

**Methods:** We conducted a questionnaire-based online survey among all 700 members of the Netherlands Orthopaedic Association, consisting of 23 questions on the definition, classification, diagnosis and treatment of persistent wound leakage after joint arthroplasty.

**Results:** The questionnaire was completed by 127 respondents, representing 68% of the Dutch hospitals that perform orthopaedic surgery. The results showed wide variation in the classification, definition, diagnosis and treatment of persistent wound leakage among Dutch orthopaedic surgeons. 56.7% of the respondents used a protocol for diagnosis and treatment of persistent wound leakage, but only 26.8% utilized the protocol in every patient. Most respondents (59.1%) reported a maximum period of persistent wound leakage before starting non-surgical treatment of 3 to 7 days after index surgery and 44.1% of respondents reported a maximum period of wound leakage of 10 days before converting to surgical treatment.

**Conclusions:** The wide variety in clinical practice underscores the importance of developing an evidence-based clinical guideline for the diagnosis and treatment of persistent wound leakage after joint arthroplasty. To this end, a nationwide multicenter randomized controlled trial will be conducted in the Netherlands, which may provide evidence on this important and poorly understood topic.

Key words: Periprosthetic joint infection, wound leakage, wound drainage, arthroplasty, DAIR

## Introduction

The diagnosis and treatment of persistent wound leakage is an important and poorly understood topic in the field of joint arthroplasty. Persistent wound leakage after total knee and hip arthroplasty is associated with a higher risk of developing periprosthetic joint infection (PJI).<sup>1-5</sup> PJI is a serious complication with great impact on a patient's physical functioning and quality of life. Moreover, PJI is a high financial burden for society. Additional medical costs of PJI are approximately €30,000 per patient,<sup>6,7</sup> with even higher societal costs because of productivity loss, home care and informal care provided by relatives. Unfortunately, there are no evidence-based guidelines for the diagnosis and treatment of persistent wound leakage after joint arthroplasty.

Numerous issues hamper the development of sound guidelines. First of all, research on wound leakage is hard, as PJI is the major endpoint of wound leakage treatment, which has a low incidence.<sup>8</sup> Secondly, there is no uniformly accepted definition of wound leakage or when to call it persistent. This lack of clear definitions hampers comparison of clinical reports to such an extent that there is no clear evidence for any treatment modality for persistent wound leakage. Finally, in clinical practice the amount of drainage may also play a role in the decision-making process, e.g. agreement on the optimal treatment of severe persistent wound leakage is usually easier than agreement on the treatment of less severe wound leakage.

As a result of this lack of clarity, there is still insufficient evidence for the development of a clinical guideline. In 2013 consensus statements on current practices for prevention, diagnosis and management of PJI were developed during the first International Consensus Meeting (ICM) on PJI.<sup>9</sup> One of these statements suggested that wound leakage is considered to be persistent when it continues for more than three days after index surgery. Moreover, they stated that surgical management of persistent wound leakage should be performed without delay if wound leakage persists for five to seven days after index surgery.<sup>10</sup> However, there is no definitive evidence for these statements, as there have been no randomized controlled trials on persistent wound leakage.

Without a guideline, clinical practice in orthopaedic hospitals varies widely. Moreover, there is no insight into the modalities used for diagnosis and treatment of persistent wound leakage after joint arthroplasty. This paper reports the results of a questionnaire-based online survey among Dutch orthopaedic surgeons on current care for persistent wound leakage after joint arthroplasty. The survey is part of the preparation for a nationwide multicenter

randomized controlled trial in the Netherlands on the optimal treatment of persistent wound leakage after total knee and hip arthroplasty.

## Methods

### Procedure

To evaluate current clinical practice of Dutch orthopaedic surgeons on persistent wound leakage after knee and hip arthroplasty, a questionnaire-based online survey was sent to all 700 members of the Netherlands Orthopaedic Association (NOV), working as orthopaedic surgeons in Dutch hospitals. Surveys completed by residents and members working outside the Netherlands were excluded. The web-based survey tool used for this questionnaire was google.forms. In January 2016 the questionnaire was disseminated by the NOV via e-mail invitation with a link to the survey. Reminder e-mails were sent after two and four weeks to increase the response rate. Data collection was closed six weeks after sending the first e-mail.

### Questionnaire

The questionnaire consisted of 23 questions regarding the definition, classification, diagnosis and treatment of persistent wound leakage after arthroplasty (Supplementary Material). The questionnaire was developed by the LEAK-study group (LEakage After Knee and hip arthroplasty). This group was appointed by the Netherlands Orthopaedic Association (NOV) and its Consortium Orthopaedic Research (CORE), as part of the preparation for a nationwide multicenter randomized controlled trial on the treatment of persistent wound leakage after total knee and hip arthroplasty. The LEAK-study group involved 25 members who are experts in the field of prosthetic joint infections (orthopaedic surgeons, epidemiologists, researchers and an infectious disease specialist). Three consensus rounds were used to form the final questionnaire (Supplementary Material).

### Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics (version 23.0, Chicago, USA). Results were analyzed using descriptive statistics.

## Results

### Respondents

A total of 127 respondents filled in the questionnaire (18.1% of NOV members), representing 70 of all 103 institutions where knee and hip arthroplasty surgeries are performed (68.0%). Most respondents work in general non-training hospitals

(61.4%) and 48.8% of the respondents had more than ten years of working experience (Table 1).

**Table 1.** Descriptives of respondents (n=127)

Variable	Value	Respondents (%)
Clinic type	General hospital	78 (61.4%)
	Orthopaedic training hospital	39 (30.7%)
	University hospital	10 (7.9%)
Experience in years	0-10	65 (51.2%)
	10-20	38 (29.9%)
	>20	24 (18.9%)

### Classification and definition of wound leakage

Most respondents did not use a classification system for wound leakage (81.2%) (Table 2). Of the 24 respondents who reported using a classification system, 12 referred to their definition of wound leakage in days (9.4%) and the other 12 all used different classification systems (9.4%).

Just over half of the respondents (51.2%) used a definition of persistent wound leakage, based on duration of wound leakage after index surgery (Table 2). The used cut-off points showed a large range of 1 to 14 days. Of the 65 respondents who used a definition of persistent wound leakage, 24 defined wound leakage as persistent when present for more than five days (36.9%), 11 as present for more than seven days (16.9%) and 19 for more than ten days (29.2%) (Figure 1a).

### Protocol for persistent wound leakage

More than half of the respondents used a protocol for diagnosis and treatment of persistent wound leakage (56.7%), but only 26.8% utilized the protocol in every patient. Patients were regularly discharged by 48.8% of the respondents regardless of wound leakage. A similar percentage of respondents almost never discharged patients with wound leakage (43.3%). The majority of respondents reported monitoring patients after discharge (90.2%), e.g. via telephone consultation (Table 2).

### Diagnostic modalities

Most clinical parameters used to evaluate persistent wound leakage were redness (92.9%), fever (92.9%), pain (69.3%), course of recovery (67.7%) and/or swelling (52.7%). Warmth was evaluated by fewer respondents (38.6%). Nearly all respondents used a combination of at least three clinical parameters (86.6%) (Figure 2a). The most popular combination was redness, fever, course of recovery and pain (used by 42.5% of the respondents), with another 27.5% of the respondents evaluating these parameters in combination with warmth and swelling.

For inflammatory parameters, plasma C-reactive protein (CRP) was used as a diagnostic modality by 92.1% of respondents. Similarly, most (82.7%) perceived CRP as the most important inflammatory parameter in persistent wound leakage. Moreover, 70.9% of the respondents felt that the trend or dynamics of CRP are important.

**Table 2.** Definition, classification and protocol for wound leakage (n=127)

Variable	Value	Respondents (%)
Classification for wound leakage	Yes	24 (18.8%)
	No	103 (81.2%)
Uniform definition of wound leakage	Yes	65 (51.2%)
	No	62 (48.8%)
Uniform protocol in case of wound leakage	Yes, used in all cases	34 (26.8%)
	Yes, not always used	38 (29.9%)
	No	55 (43.3%)
Discharge patients with wound leakage	Yes, always	4 (3.2%)
	Yes, regularly	62 (48.8%)
	No, almost never	55 (43.3%)
Monitoring wound leakage after discharge*	No, never	6 (4.7%)
	Yes	111 (90.2%)
	No	12 (9.8%)

\* 4 missing values

### Non-surgical treatment modalities

The maximum period of persistent wound leakage before starting non-surgical treatment was 3 to 7 days according to most respondents (59.1%) (Figure 1b). 20.5% of respondents stated no maximum period before starting non-surgical treatment, as they only use surgical treatment modalities. The miscellaneous group used clinical presentation instead of the above-mentioned time-based parameter (10.2%).

Regarding non-surgical treatment modalities for persistent wound leakage most respondents used wound care (60.6%), bed rest (49.6%), pressure bandages (36.2%), admittance (23.6%) and antibiotics (23.6%). A wide variety of combinations was reported (in total 36), all comprising small groups (ranging from 1 to 8 respondents): 54.4% of the respondents used 1-2 non-surgical treatment modalities, 40.9% used 3-4 modalities and 4.7% reported using 5-7 modalities (Figure 2b). The most popular combination was admittance and wound care (5.5%).

### Surgical treatment modalities

Most respondents reported a maximum period of wound leakage before converting to surgical treatment of 10 days after index surgery (44.1%) (Figure 1c), yet with a wide range from 5 to 21 days. From the miscellaneous group (31.5%), 14

respondents favored a 14-day cut-off, while another 14 respondents stated basing their decision on aspects other than duration of wound leakage (e.g. type and/or amount of wound leakage, clinical parameters and/or inflammatory parameters).

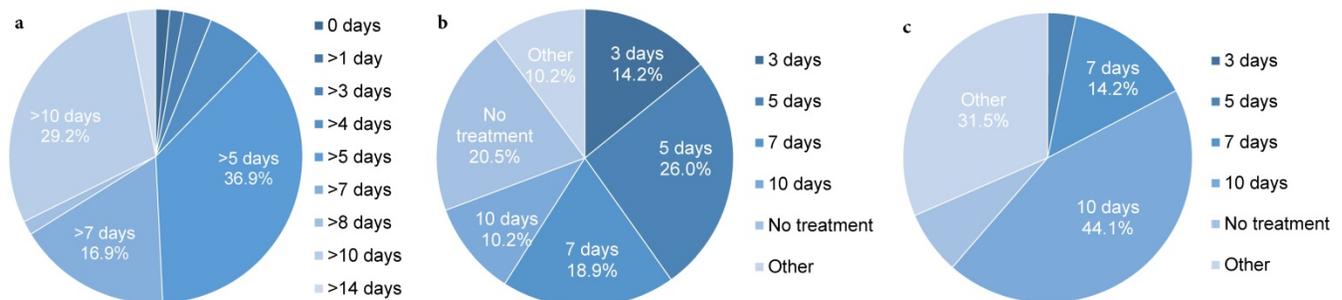
The most-used surgical treatment modalities were lavage (96.1%), obtaining cultures (94.4%), surgical debridement (79.5%), antibiotics (77.2%) and exchange of mobile components (67.7%). The majority of the respondents (52.0%) favored a combined use of all these five treatment modalities as a surgical treatment regime; 34.6% of respondents used 3-4 surgical treatment modalities and 13.4% used 1-2 modalities (Figure 2c). The miscellaneous group (3.1%) comprised of two respondents using local gentamicin carriers, one removing the prosthesis and one other respondent performing only superficial debridement in case of an intact joint capsule and iliotalibial tract.

### Discussion

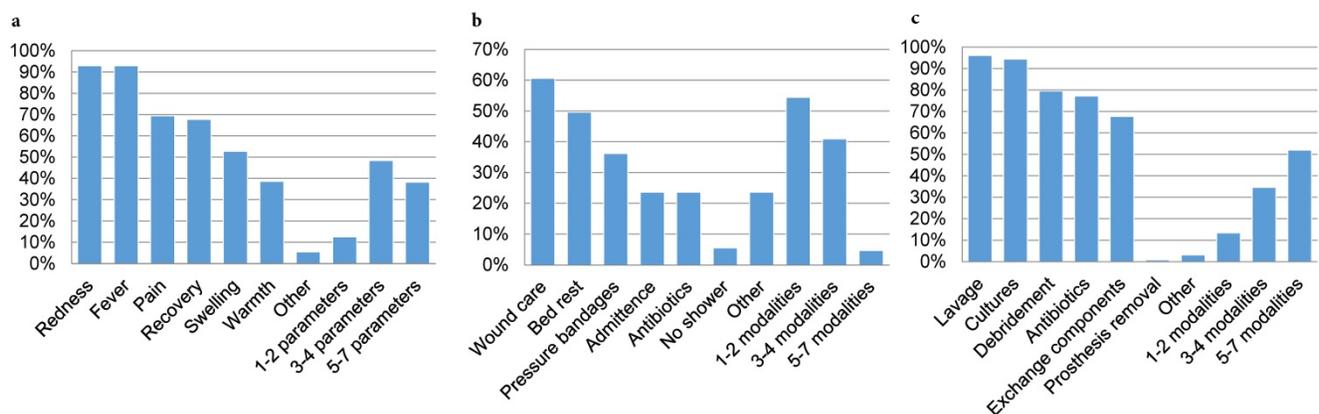
In this online survey we evaluated current Dutch orthopaedic care for persistent wound leakage after joint arthroplasty. This survey revealed considerable

variation in clinical practice among Dutch orthopaedic surgeons in terms of classification, definition, diagnosis and treatment of persistent wound leakage after joint arthroplasty. This variety in clinical practice is likely the result of a lack of evidence-based guidelines, caused by the scarce evidence on this topic.<sup>1-5,10-12</sup>

Regarding the definition of persistent wound leakage after joint arthroplasty most respondents based the definition on the duration of wound leakage after index surgery. Preferred cut-off points were more than five days and more than ten days, yet with a large range (1 to 14 days). This lack of agreement is in accordance with reports in the literature, reporting using time (with a range of 2 to 7 days), presence of microbial content or type of secretion (purulent, hematogenous or clear) as definition.<sup>1-5,11-16</sup> The ICM statements define persistent wound leakage as a wound leaking >2 x 2cm for more than three days, arguing that this time frame would allow for earlier intervention and may limit the claimed adverse consequences (e.g. PJI).<sup>10</sup> Still, there is no scientific data confirming this statement.



**Figure 1. Definition of persistent wound leakage and maximum period of wound leakage before start of (non-)surgical treatment (n=127)**  
 1a. Definition of wound leakage (in days) 1b. Number of days before start non-surgical treatment 1c. Number of days before start surgical treatment



**Figure 2. Clinical parameters, non-surgical treatment modalities and surgical treatment (n=127)**  
 2a. Clinical parameters 2b. Non-surgical treatment modalities 2c. Surgical treatment modalities.

In the Netherlands there is dearth of a uniform approach to the classification, definition, diagnosis and treatment of persistent wound leakage. Only 18.7% of respondents used a classification and all used a different classification. In the literature there is a complete lack of data regarding amount of wound leakage, while this amount and its dynamics play a large role in the decision-making process. This missing classification of type and amount of wound leakage impairs comparison and interpretation of the scarce literature on the topic.

This survey showed that there is no consensus on a protocol. Only 26.5% used a protocol consistently, and 30.5% did not use the protocol in all cases. In the literature only Maathuis et al. have described a standardized method to approach persistent wound leakage after arthroplasty.<sup>1</sup> Compared to an *ad hoc* approach, their algorithm resulted in fewer open debridements (17% versus 30%) and a higher salvage percentage (95% versus 85%).

The clinical parameters most respondents used when evaluating persistent wound leakage were redness, fever, pain, swelling and a course of recovery. A combination of at least two clinical parameters was used by nearly all respondents (96.9%). However, 24 different combinations were reported, underscoring an apparent lack of evidence and consensus for an optimal combination of clinical parameters.

Our results showed that orthopaedic surgeons used several clinical and inflammatory parameters to provide the necessary information to guide clinical decision-making. For inflammatory parameters, 92.1% of respondents used CRP at some point in their decision-making process. Moreover, most respondents reported CRP to be the primary parameter and 70.9% reported that the trend or dynamics of CRP are important - e.g. a rise in CRP is considered a worrisome sign, whereas a decrease is generally interpreted as a sign of absence of infection. Nevertheless, responses to the exact use of CRP were wide and diverse, probably in relation to the fact that an elevated CRP, as well as some other clinical infectious symptoms (such as fever and tachycardia), may be a physiological response in the early postoperative period.<sup>17-23</sup>

In this survey the maximum period of wound leakage before starting non-surgical treatment was three to seven days after index surgery. The most popular treatment modalities included wound care, bed rest, pressure bandages and/or antibiotics. Still, more than 30 combinations of treatment modalities were used, stressing the lack of consensus on optimal non-surgical treatment. Literature on this topic is

limited, suggesting several days of immobilization,<sup>15,16</sup> sterile dressings,<sup>3</sup> and/or antibiotics.<sup>3</sup> The use of antibiotics among 23.4% of respondents was a surprising and disturbing finding, as the efficacy of antibiotic treatment in persistent wound leakage after arthroplasty has not been studied. Antibiotics can also have substantial negative effects, such as increased risk of resistance, poor penetration into the biofilm, and complicated early diagnosis and treatment of infection, given that they can mask infection and confound culture findings.<sup>10,15</sup> For these reasons, the ICM advises against the use of antibiotics in persistent wound leakage after joint arthroplasty.<sup>9,10</sup>

Most respondents (43.8%) convert to surgical treatment if wound leakage is present for ten days after index surgery, implying a non-surgical treatment period of three to seven days. The literature offers little guidance on this topic, but suggests that wound leakage more than five to nine days after arthroplasty should be managed by surgical treatment to give a higher chance of preventing PJI.<sup>2-4,14,16</sup> Based on these findings, the ICM states that surgical treatment should be performed if wound leakage persists for more than five to seven days.<sup>10</sup> However, it seems reasonable to use parameters other than merely duration of wound leakage in the clinical decision-making process. In this survey a minority of respondents used other aspects, such as type or amount of wound leakage, clinical parameters and/or infectious parameters.

A total of 16 combinations were reported as surgical treatment protocol. The majority (52.3%) favored a combined protocol consisting of five modalities (surgical debridement, lavage, cultures, exchange of mobile components, and start of antibiotic treatment). These modalities are comparable to the ICM's, stating a moderate agreement on deep open debridement, cultures (>3) and modular component exchange.<sup>10,24</sup>

This survey can be viewed as a fair representation of the practices of the Dutch orthopaedic community. The main weakness of this study is that it is by design a questionnaire-based survey. Although this study design led to a relatively low response rate of 18.1% among all NOV members, the respondents represented the majority (68.0%) of orthopaedic clinics, which leads to a reasonable assumption that respondents provided a correct representation of clinical practice in the Netherlands. Respondents were not obliged to fill in the name of the hospital they worked in, since it was anticipated that orthopaedic surgeons could consider this a barrier for filling in the survey. Because of this, 15 respondents did not provide data on the hospital they

worked in. Taking this into account, the actual representation of orthopaedic clinics may be even higher than 68.0%.

In conclusion, the data from this nationwide survey among Dutch orthopaedic surgeons on persistent wound leakage after joint arthroplasty demonstrated a wide variation in clinical practice of classification, definition, diagnosis and treatment of persistent wound leakage. This underscores the lack of consensus, which is mainly due to a dearth of clear evidence on the correct diagnosis and treatment of wound leakage. This survey may be representative for current daily clinical practice of the global orthopaedic community and stresses the need for further research on this important topic.

## Abbreviations

CORE: Consortium Orthopaedic Research; ICM: International Consensus Meeting; LEAK: LEakage After Knee and hip arthroplasty; NOV: Netherlands Orthopaedic Association; PJI: periprosthetic joint infection.

## Supplementary Material

Questionnaire. <http://www.jbji.net/v02p0202s1.pdf>

## Acknowledgements

The authors would like to thank the Dutch orthopaedic community for completing the questionnaire.

## The LEAK study group

The LEAK study group includes: DC Baas, SBT Bolder, PK Bos, B Bosmans, MG Bouma, AMJ Burgers, D Das, RLM Deijkers, B Dijkstra, NHH de Esch, HB Ettema, JAP Geurts, FJA Hagemans, JGE Hendriks, RMHA Huis in 't Veld, OP van der Jagt, L Janssen, LM Jutten, P van Kampen, LCM Keijser, RWTM van Kempen, P Kingma, YV Kleinlugtenbelt, BAS Knobben, KLM Koenraadt, S Koeter, CM Kooijman, JW Kootstra, NP Kort, K Kremers, O Lambers Heerspink, G Meermans, DJF Moojen, PA Nolte, BF Ongkiehong, JJW Ploegmakers, M Reijman, WHC Rijnen, MGM Schotanus, MC van der Steen, H Verburg, AMJS Vervest, E de Visser, HCh Vogely, A de Vries, BCH van der Wal, RJP van der Wal, NW Willigenburg, P van der Woude, WP Zijlstra, BC van der Zwaard.

## Ethical approval

Consultation with the Institutional Review Board of the University Medical Center Groningen indicated that approval of this study by the Institutional Review Board is not required, in

accordance with the Dutch act for medical research involving human subjects (Wet Medisch Onderzoek).

## Contribution of authors

All authors contributed to the conception of this study and the revision of this manuscript. FW, WW and PJ conducted the study and performed the data analyses. They wrote the manuscript in cooperation with CL and MS. WW designed the questionnaire.

## Competing Interests

The authors have declared that no competing interest exists.

## References

1. Maathuis P, de Hartog B and Bulstra SK. Timing of open debridement for suspected infection of joint prosthesis: a report on 551 patients. *Heal (San Fr)*. 2009; 20(5): 541-5.
2. Weiss A and Krackow K. Persistent wound drainage after primary total knee arthroplasty. *J Arthroplasty*. 1993; 8(3): 285-9.
3. Jaber FM, Parvizi J, Haytmanek CT, et al. Procrastination of wound drainage and malnutrition affect the outcome of joint arthroplasty. *Clin Orthop Relat Res*. 2008; 466(6): 1368-71.
4. Saleh K, Olson M, Resig S, et al. Predictors of wound infection in hip and knee joint replacement: results from a 20 year surveillance program. *J Orthop Res*. 2002; 20(3): 506-15.
5. Patel VP, Walsh M, Sehgal B, et al. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. *J Bone Joint Surg Am*. 2007; 89(1): 33-8.
6. Kurtz SM, Lau E, Schmier J, et al. Infection burden for hip and knee arthroplasty in the United States. *J Arthroplasty*. 2008; 23(7): 984-91.
7. Kallala RF, Ibrahim MS, Sarmah S, et al. Financial analysis of revision knee surgery based on NHS tariffs and hospital costs. Does it pay to provide a revision service? *Bone Joint J*. 2015; 97B(2): 197-201.
8. Kurtz SM, Ong KL, Lau E, et al. 2010. Prosthetic joint infection risk after TKA in the medicare population. *Clin Orthop Relat Res*. 2010; 468(1): 52-6.
9. Parvizi J, Gehrke T and Chen AF. Proceedings of the international consensus on periprosthetic joint infection. *Bone Joint J*. 2013; 95B(11): 450-2.
10. Ghanem E, Heppert V, Spangehl M, et al. Wound management. *J Orthop Res*. 2014; 32: S108-19.
11. Butt U, Ahmad R, Aspros D, Bannister GC. Factors affecting wound ooze in total knee replacement. *Ann R Coll Surg Engl*. 2011; 93(1):54-6.
12. Surin VV, Sundholm K and Bäckman L. Infection after total hip replacement. With special reference to a discharge from the wound. *J Bone Joint Surg Br*. 1983; 65(4): 412-8.
13. Hansen E, Durinka JB, Costanzo JA, et al. Negative pressure wound therapy is associated with resolution of incisional drainage in most wounds after hip arthroplasty. *Clin Orthop Relat Res*. 2013; 471(10): 3230-6.
14. Dennis DA. Wound complications in total knee arthroplasty. In: *Sculco TP, ed. Knee arthroplasty, 1st ed.* New York, USA: Springer Vienna. 1997: 163-9.
15. Vince K, Chivas D and Droll KP. Wound complications after total knee arthroplasty. *J Arthroplasty*. 2007; 22(4 Suppl 1): 39-44.
16. Lonner JH and Lotke PA. Aseptic complications after total knee arthroplasty. *J Am Acad Orthop Surg*. 1999; 7(5): 311-24.
17. Aalto K, Osterman K, Peltola H, et al. Changes in erythrocyte sedimentation rate and C-reactive protein after total hip arthroplasty. *Clin Orthop Relat Res*. 1984; 184: 118-20.
18. Bilgen O, Atici T, Durak K, et al. C-reactive protein values and erythrocyte sedimentation rates after total hip and total knee arthroplasty. *J Int Med Res*. 2001; 29(1): 7-12.
19. Moreschini O, Greggi G, Giodano M, et al. Postoperative physiopathological analysis of inflammatory parameters in patients undergoing hip or knee arthroplasty. *Int J Tissue React*. 2001; 23(4): 151-4.
20. Niskanen R, Korkala O, Pammo H. Serum C-reactive protein levels after total hip and knee arthroplasty. *J Bone Joint Surg Br*. 1996; 78(3): 431-3.
21. Shih LY, Wu JJ and Yanc DJ. Erythrocyte sedimentation rate and C-reactive protein values in patients with total hip arthroplasty. *Clin Orthop Relat Res*. 1987; 225: 238-246.
22. White J, Kelly M and Dunsmuir R. C-reactive protein level after total hip and knee replacement. *J Bone Joint Surg Br*. 1998; 80(5): 909-11.
23. Honsawek S, Deepaisarnsakul B, Tanavalee A, et al. Relationship of serum IL-6, C-reactive protein, erythrocyte sedimentation rate, and knee skin temperature after total knee arthroplasty: a prospective study. *Int Orthop*. 2011; 35(1): 31-5.
24. Zmistowski B and Parvizi J. Identification and treatment of infected total hip arthroplasty. *Expert Rev Anti Infect Ther*. 2012; 10(4): 509-18.