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Translation and validation of the Greek version of the "ASEPSIS" scoring method for orthopaedic wound infections

Panagiota Copanitsanou[a,*], Vasileios A. Kechagias[b], Petros Galanis[c], Theodoros B. Grivas[d], Peter Wilson[e]

[a] General Hospital of Piraeus "Tzaneio", Orthopaedics and Traumatology Department, National and Kapodistrian University of Athens, Athens, Greece
[b] Hospital of Volos, PhD(c), MSc, MD, Greece
[c] Center for Health Services Management and Evaluation, National & Kapodistrian University of Athens, Department of Nursing, Greece
[d] General Hospital of Piraeus "Tzaneio", Head of the Department of Orthopaedics and Traumatology, Greece
[e] Department of Microbiology, University College London Hospitals, London, UK

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ABSTRACT

Introduction: The ASEPSIS scoring method represents an important instrument for assessing surgical wounds for infections. The purpose of this study was to translate and validate the ASEPSIS in Greek.

Methods: The ASEPSIS was translated from English to Greek, back-translated to English, and reviewed by an expert committee. Reliability and validity analyses were performed in a sample of 111 consecutive orthopaedic patients. Patients were assessed during hospitalisation (using the ASEPSIS) and at three months after discharge (by phone, through questions about wound healing).

Results: Face validity was considered to be very good. The surgical wound infection rate was 6.3% with the Centers for Disease Control and Prevention criteria and 3.6% with the ASEPSIS (i.e. score ≥ 21) ($p < 0.001$). At three months, 7.4% of the participants reported they were given antibiotics for wound infection and 5.4% needed a rehospitalisation. The ASEPSIS score was correlated to the therapeutic administration of antibiotics ($p = 0.001$) and the need for rehospitalisation ($p < 0.001$) during the follow-up. The inter-rater agreement was 90%.

Conclusions: The Greek version of the ASEPSIS can be used by both surgeons and nurses. However, it should be used with caution until more studies are conducted with larger samples and in patients with different surgical procedures.

Introduction

Surgical wound infections are difficult to define, because of their wide range of possible features. There are several definitions, the most popular being the definition of the Centers for Disease Control and Prevention (CDC), the United Kingdom Nosocomial Infection National Surveillance Scheme (NINSS) and the ASEPSIS scoring method (Ashby et al., 2010; Bruce et al., 2001), while there is no validated universal system for their assessment (Petrica et al., 2009).

The most widely recognised definition of infection is the CDC criteria (Petrica et al., 2009), where surgical wound infections are classified into superficial incisional (where only the skin/subcutaneous tissue are involved), deep incisional (where fascial and muscle layers are involved) and organ/space infections (i.e. affecting any space other than the incision, which was manipulated during the operation) (CDC, 2017). However, CDC criteria also include "diagnosis by physician", which can be subjective. Alternatively, the ASEPSIS is an objective scoring system based on the presence of clinical findings (Hedrick et al., 2015).

The ASEPSIS is a quantitative method that provides a score related to the severity of infection using objective criteria based on wound appearance and the clinical consequences of the infection (Petrica et al., 2009). ASEPSIS is an acronym for: Additional treatment; Serous discharge; Erythema; Purulent exudate; Separation of deep tissues; Isolation of bacteria; and Stay as inpatient for a prolonged period (over fourteen days). Although it was first used in wounds after cardiothoracic surgery, it has been widely used in different surgical settings and patients (Bruce et al., 2001), including patients undergoing orthopaedic surgeries (Chiew and Theis, 2007; Romanò et al., 2016). Furthermore, the ASEPSIS has good reliability (Bruce et al., 2001; Wilson et al.,

* Corresponding author. General Hospital of Piraeus Tzaneio 18536, Piraeus, Greece.
E-mail addresses: giwta_c@hotmail.com, gcopanitsan@nurs.uoa.gr (P. Copanitsanou).

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1986a) and it is simple to use; therefore we believe it is the most suitable instrument to use in Greece on a regular basis.

Background

Surgical wound infections are among the most common healthcare-associated infections and are associated with longer hospital stays, additional surgical procedures, treatment in intensive care units, and higher mortality (European Centre for Disease Prevention and Control, 2018).

Surgical wound infections may occur up to thirty days after a surgery or up to one year after a surgery in which implants are used (Owens and Stoessel, 2008). Every surgical wound is colonized by bacteria, but infection is presented in only a few patients (Alexiou et al., 2017), depending on wound class, type of surgery, and comorbidity (CDC, 2017). Around two thirds of infections concern the surgical wound and about a third the spaces that were accessed during the operation (Alexiou et al., 2017; Martone et al., 1992). Of all orthopaedic surgeries, the open reduction of fracture (Gikas et al., 2004; Roumbelaki, 2008), hip prostheses and other operations of the musculoskeletal system (Gikas et al., 2004), and spondylodesis (Roumbelaki, 2008) are those that are most frequently associated with the development of a surgical wound infection.

According to the European Centre for Disease Prevention and Control (2018) data from fifteen European countries, there has been a significant increase for surgical wound infections after laminectomies (rate 0.9%) and a significant decrease after total knee arthroplasties (0.5%) (European Centre for Disease Prevention and Control, 2018). In the United States of America, the rate of periprosthetic infection is higher than that of Europe [2.0%–2.4% after total hip/knee arthroplasties (Kurtz et al., 2012), 0.98% after shoulder arthroplasty (Padegimas et al., 2015)]. In England, the wound infection rate is 0.6% and 0.5% for primary hip and knee arthroplasty respectively (1.3% and 1.4% for a revision, respectively), 0.7% for reduction of long bone fracture, and 1% for repair of fractured neck of femur. The highest risk for infection in hip prosthesis is for surgery to treat avascular necrosis (1.7%) while, in knee prosthesis, the risk is highest for reoperation after fracture (5.1%). Osteomyelitis is an infrequent infection (Public Health England, 2017).

Unfortunately, there are no available data in Greece about the frequency of surgical wound infections in orthopaedic patients, as there is no national surveillance system. In an earlier surveillance study, which took place in 15% of all Greek hospitals, the prevalence of all surgical wound infections was 4.5% in 1999 and 4.2% in 2002 (Gikas et al., 2004). Such surveys have been performed repeatedly and their results have been published in several articles (Gikas et al., 1999, 2002). In another Greek study of patients undergoing general surgery, 4.2% of patients were recognised as having a surgical wound infection after a clean operation and 12.9% after a clean-contaminated operation (Tourmousoglou et al., 2008). The authors commented that these rates were higher than expected and most infections were diagnosed post-operatively, which means that surveillance after discharge was very important (Tourmousoglou et al., 2008).

The pathogens that cause the infection usually originate from the patient's endogenous flora, with the most commonly isolated organisms being *Staphylococcus aureus* (Kanellakopoulou et al., 2009; Owens and Stoessel, 2008), coagulase-negative staphylococci, *Enterococcus*, and *Escherichia coli* (Owens and Stoessel, 2008). *Staphylococcus aureus* is the main cause of surgical wound infections in orthopaedic surgery; in primary total hip arthroplasties the proportion of infections due to *Staphylococcus aureus* was highest in the uncemented compared to the cemented and hybrid fixation groups, while the cemented group had the highest proportion due to Enterobacteriaceae compared to other fixation groups (Public Health England, 2017). The surveillance periods for surgical wound infection may last for thirty days (e.g. after a limb amputation) or for up to ninety days (e.g. after a hip/knee prosthesis) (CDC, 2017). The CDC guidelines for the prevention of surgical wound infections emphasise good patient preparation, attention to asepsis/surgical technique and antimicrobial prophylaxis (Owens and Stoessel, 2008).

Despite the relatively low rates of surgical wound infections after orthopaedic surgery, these infections are associated with increased morbidity and mortality, healthcare resource utilisation, and costs (Poultsides et al., 2013; Patel et al., 2016; Wijeratna et al., 2015). The development of infection after fracture fixation can delay healing and lead to permanent functional loss, or even amputation (Metsemakers et al., 2017; Henkelmann et al., 2017). Periprosthetic joint infection is associated to high failure rates (Cherubino et al., 2013; Mooney et al., 2018) and poor functional outcomes (Cherubino et al., 2013). Orthopaedic patients with surgical wound infections are at greater risk for reoperations (Kamath et al., 2015; Henkelmann et al., 2017), which are associated with longer operating times, increased blood loss, and increased complications (Vanhegan et al., 2012). Surgical wound infections in orthopaedic patients also lead to longer hospitalisations (Kapadia et al., 2014, 2016; Kamath et al., 2015) and more readmissions (Nacke et al., 2013; Kapadia et al., 2014; Westermann et al., 2016). Finally, orthopaedic wound infections are associated with increased costs (Kapadia et al., 2016; Padegimas et al., 2015; Rennert-May et al., 2018a), which are up to 6.5-times higher compared to uninfected patients (Metsemakers et al., 2017). These higher costs are attributed to the reoperations due to the infection (Vanhegan et al., 2012; Lüthje et al., 2014; Kamath et al., 2015), to hospital readmissions (Kurtz et al., 2017; Public Health England, 2017), and the higher hospitalisation costs (Kurtz et al., 2008).

The use of antibiotics in Greece may not follow the recommended guidelines, with prolonged or erroneous administration of antibiotics (Kambaroudis et al., 2010). For example, it has been found that antibiotic administration was displaying an upward trend; from 4 days in 1999 to 6 days in 2000 (Gikas et al., 2004). This not only means increased costs, but may be contributing to antibiotic-resistance (Gikas et al., 2004). However, many physicians insist on administration of multiple doses of antibiotics; according to the Norwegian Arthroplasty Registry; in 85% of arthroplasty operations, three to four doses of antibiotics were administered within the first postoperative day, whereas in the remaining operations the duration of prophylaxis was extended to 4 days (Engesaeter et al., 2003), which is unnecessary.

The assessment of surgical wounds according to different definitions does not only concern everyday clinical practice, but it is also relevant to research studies. Surgical site infections in the literature are usually assessed by CDC definitions (Rosenthal et al., 2013), by signs/symptoms (e.g. wound dehiscence, pain, tenderness, localised swelling, redness, heat, purulent discharge) (Theodoridis et al., 2011), by the diagnosis of a surgeon (Chiew and Theis, 2007; Tourmousoglou et al., 2008), according to criteria such as fever, signs of inflammation, radiological findings, a new operation confirming the infection (Kanellakopoulou et al., 2009), and by the ASEPSIS scoring method, presence of pus alone, and assessment by a microbiologist (Chiew and Theis, 2007). In Greek prevalence studies, the CDC criteria were applied; however, in the majority of Greek studies the method of assessment is not reported.

The implementation of different assessment methods makes comparisons of surveillance data, both over time in the same hospital as well as among hospitals, difficult: although such comparisons could provide information for the improvement of infection control practices (Roumbelaki et al., 2008). A single, standard definition of surgical wound infection is, therefore, needed so that comparisons are valid and useful (Petrica et al., 2009). Rates of surgical wound infections vary considerably between different countries: ranging from 2.6% to 14.3% (Gikas et al., 2004), which may reflect not only the effect of different practices, but that of the different assessment methods as well. In Europe, national or regional surveillance systems exist in Austria, Czech Republic, Estonia, Finland, France, Germany, Hungary, Italy, Lithuania,

Table 1
Description of ASEPSIS Scoring Method and CDC criteria for wound infection (Wilson et al., 1986a; Centers for Disease Control and Prevention, 2017).

ASEPSIS Scoring Method			CDC criteria	
Additional treatment		Points	**Superficial incisional infection**	• Infection occurs within 30 days after the surgery and involves only skin and subcutaneous tissue and at least one of the following: a Superficial purulent drainage b Organisms isolated from an aseptically obtained culture from the superficial incision/subcutaneous tissue c Superficial incision needed to be opened by surgeon/attending physician/other designee and culture or non-culture based testing is not performed **and** patient has at least one of the following: pain or tenderness, localised swelling, erythema, or heat d Diagnosis of a superficial incisional infection by surgeon/attending physician/other designee
	Antibiotics	10	**Deep incisional infection**	• Infection occurs within 30 days after the surgery if no implant is left in place or within 90 days if implant is left in place and involves deep soft tissues (e.g., muscle layers) and at least one of the following: a Deep incisional purulent drainage b Deep incision that spontaneously dehisces, or is deliberately opened/aspirated by surgeon and organism is identified by a culture or non-culture based microbiologic testing method which is performed for clinical diagnosis/treatment or culture or non-culture based microbiologic testing method is not performed **and** patient has at least one of the following: fever (> 38 °C), localised pain or tenderness (a culture or non-culture based test that has a negative finding does not meet this criterion) c An abscess or other evidence of infection involving the deep incision that is detected on anatomical or histopathologic exam or imaging test
	Drainage of pus under local anaesthetic	5	**Organ/Space infection**	• Infection occurs within 30 days after the surgery if no implant is left in place or within 90 days if implant is left in place and involves any part of the body deeper than the fascial/muscle layers, that is opened or manipulated during the operative procedure and at least one of the following: a Purulent drainage from a drain in the organ/space b Organisms isolated from an aseptically obtained culture of fluid/tissue in the organ/space by a culture or non-culture based microbiologic testing method which is performed for clinical diagnosis/treatment c An abscess or other evidence of infection involving the organ/space that is detected on anatomical or histopathologic exam or imaging test **and** meets at least one criterion for a specific organ/space infection (e.g., osteomyelitis, joint or bursa, periprosthetic joint infection, disc space)
	Debridement of wound under general anaesthetic	10		
Serous discharge		0–5		
Erythema		0–5		
Purulent exudate		0–10		
Separation of deep tissues		0–10		
Isolation of bacteria		10		
Stay in hospital over 14 days		5		

Malta, the Netherlands, Norway, Portugal, Romania, Slovakia, and United Kingdom (European Centre for Disease Prevention and Control, 2017). Other national surveillance systems exist in Canada (Rennert-May et al., 2018b), United States of America (Centers for Disease Control and Prevention, 2018), and Japan (Tsutsui et al., 2018), to name a few. Both in England and United States of America surgical wound infections are defined according to the CDC criteria.

In a previous study, we had implemented the ASEPSIS to examine the frequency of surgical wound infections and their correlations with patient and surgery factors, in patients who were undergoing orthopaedic surgeries. In that study, 76.6% of patients had an ASEPSIS score which indicated satisfactory healing. The ASEPSIS score was correlated with factors that had more to do with the surgical technique and the aseptic methods rather than other factors (Copanitsanou et al., 2018c).

There is lack in the literature about how the clinical characteristics of surgical wounds should be assessed by nurses. ASEPSIS covers nine wound characteristics (those of the aforementioned acronym) which are easily assessed by nurses. Additionally, as its use does not necessitate an assessment by a surgeon/physician, as it is the case with the CDC criteria (Table 1), it may represent a useful tool for nurses working in orthopaedic or other surgical departments. The purpose of this study was to translate and validate the ASEPSIS into the Greek language. Our ultimate purpose is to use the ASEPSIS on a regular basis for the surveillance of surgical wound infections in Greek surgical departments.

Methods

Description of the ASEPSIS

A score in the ASEPSIS between “0” to “10” corresponds to satisfactory healing, while scores between “11” to “20” indicate a disturbance of healing, scores between “21” to “30” correspond to minor infection, scores between “31” to “40” correspond to moderate infection and, finally, scores higher than “41” correspond to severe infection (Wilson et al., 2006).

Ideally, 5 daily scores must be obtained (e.g., for 5 out of the first 7 postoperative days) and all ASEPSIS scores from the patient's assessments are added together to provide a total score, i.e. patients who are assessed many times have higher scores. However, the assessments can take place at least twice (e.g., when there is no need to change the wound dressings) and then a computer can generate the missing scores from adjacent points (Wilson et al., 2006). As routine and unnecessary changes of the wound dressings are avoided to prevent surgical wound infection, in this study the dressings were changed if they e.g., were very moist, had blood/exudate leakage, there was erythema, or the patient had fever (National Collaborating Centre for Women's and Children's Health, 2008).

Translation of the ASEPSIS and pilot study

Permission to translate the ASEPSIS into Greek was obtained from the original authors (Wilson et al., 1986a). The instrument was then translated into Greek by a nurse fluent in English. The aim was the translation of the contextual meaning rather than a mere literal translation. The back-translation was performed by an orthopaedic surgeon who had no knowledge of the original instrument. The translated version was then compared to the original scale and no significant differences were found. Then the scale was cross-culturally adapted by an expert committee of an orthopaedic surgeon, one nurse and the head of the orthopaedic and traumatology department. At this point only minor changes were made. Finally, the instrument was pilot tested by assessing the surgical wounds of 30 patients and it was found easy to use, while no further changes were deemed necessary. The validity and reliability in the pilot study were satisfactory (regarding convergent validity and internal consistency reliability) and no further changes were made. The inclusion and exclusion criteria for the pilot study were the same as those of the evaluation study.

The translation, using the method according to the guidelines of cross-cultural adaptation of health questionnaires by Beaton et al. (2000) may seem unusual, as this is an observation scale and not a questionnaire; however, there are no clear international guidelines for the adaptation of observation scales. In many studies, the same method of adaptation is followed.

Study design-sample

In this prospective, observational study patients were included regardless the type of orthopaedic surgical procedure, but they had to be over 18 years of age, be hospitalized in the orthopaedic department for at least two nights, be undergoing orthopaedic surgery requiring an incision (i.e. not endoscopic surgery), and give informed consent. In the case that the patient was suffering from cognitive problems (e.g. dementia), the patient's relative (who was usually an adult child) would give informed consent for participation in the study (Copanitsanou et al., 2018c). Patients' advocates can provide information on behalf of patients as long as they can confidently state they know the wants and beliefs of the person who they are advocating for and are not paid carers. When patients cannot make decisions for themselves (e.g., when they have dementia), it is usually a family member who fulfils this advocate role (Cross, 2018).

Data collection

Participants were recruited from the orthopaedic and traumatology department of a large hospital in Greece. Data were collected from September 2014 to November 2016, in two phases: (1) during hospitalisation (with direct assessment of the wound) and (2) at three months after discharge (by telephone interview).

Patients' demographic information included: age, gender, weight, height, level of education, working status, and level of comorbidity. Type of trauma and administration of antibiotics were also recorded during hospitalisation.

One orthopaedic surgeon and one nurse simultaneously assessed all wounds; they both assigned an ASEPSIS score. The surgeon also diagnosed any surgical site infection according to CDC criteria. According to CDC, a superficial incisional surgical wound infection should appear within 30 postoperative days (i.e. when the first part of the present study took place) (CDC, 2017). The results from the ASEPSIS scale were compared to CDC criteria. The two researchers did not discuss their assessments (Table 1).

At three months postoperatively, all participants were contacted by phone and were asked if the wound(s) were healed without problems. If the patients reported that there were problems in healing, they were asked what the specific problems were (e.g. need for hospitalisation/administration of antibiotics). Out of the 11 questions, 8 involved items that are assessed by the ASEPSIS (e.g. “has the wound been red?” or “has the wound discharged pus?”). The ninth criterion of the ASEPSIS (i.e., “stay as inpatient prolonged over 14 days”) did not need to be asked in the telephone interview, as we already had information about previous hospitalisation. All the questions asked in the telephone interview have been used previously (Wilson et al., 2006), except for one which was slightly altered (i.e. “Has the wound needed to be redressed?”) and one which was added (i.e. “Have you been admitted to the same hospital?”). If the participant was not able to answer the questions, their relative would answer on their behalf. In Greece, family bonds are still very strong and older people usually live with their adult children. Older adults with cognitive impairment especially depend on their children for their care, so adult children are in position to know about their parents' condition and are able to answer questions about the surgical wound.

The method of telephone interview for the assessment of surgical wounds has been used in previous studies (versus the assessment by a

Table 2
Descriptive results.

			N (%)
Gender	Female		43 (63.2)
	Male		25 (36.8)
Retired	Yes		45 (66.2)
	No		22 (32.4)
	Missing		1 (1.4)
Education	Primary school		34 (50.0)
	High school		14 (20.6)
	University/technological education		6 (8.8)
	Missing		14 (20.6)
Surgery	Fracture		32 (47.1)
	Total arthroplasty		36 (52.9)
Smoking	Yes		10 (14.7)
	No		51 (75.0)
	Missing		7 (10.3)
Weight	Low		12 (17.6)
	Normal		34 (50.0)
	High		18 (26.5)
	Missing		4 (5.9)
Comorbidities	Diabetes	Yes	11 (16.2)
		No	57 (83.8)
	Rheumatoid disease	Yes	1 (1.5)
		No	67 (98.5)
	Cardiac disease	Yes	11 (16.2)
		No	57 (83.8)
	Chronic obstructive pulmonary disease	Yes	4 (5.9)
		No	64 (94.1)
	Hypertension	Yes	33 (48.5)
		No	35 (51.5)
	Cancer	Yes	1 (1.5)
		No	67 (98.5)
	Dementia	Yes	14 (20.6)
		No	54 (79.4)
Complications	Yes		18 (26.4)
	No		42 (61.8)
	Missing		8 (11.8)

healthcare professional or the completion of written questionnaire) (Ashby et al., 2010; Reilly et al., 2005; Wilson et al., 2004); in one study, the authors concluded that patients can report up to 90% of surgical wound infections, having a specificity up to 76% (Reilly et al., 2005). Telephone surveillance has been found to be highly sensitive and specific method of identifying infections in patients who have undergone orthopaedic surgeries (Health Protection Scotland, 2010). Although in some hospitals these phone calls are thought to be time consuming and therefore postal questionnaires are used, this is not the case in Greece, where most participants are not likely to return the completed questionnaires; hence, the phone call method was chosen (Copanitsanou et al., 2018a,b).

Ethical issues

The study was approved by the hospital's Institutional Review Board. The principles of the Declaration of Helsinki (World Medical Association, 2013) were applied through all phases of the study. Informed consent was obtained from all participants. All patient data were coded and only the researchers had access to them.

Statistical analysis

Categorical variables are expressed as numbers (percentages), while continuous variables are expressed as means (standard deviation). The total ASEPSIS score was tested as a categorical variable (five categories, from “satisfactory healing” to “severe infection”). In every test, only the highest ASEPSIS scores were used, no matter who was the rater who made the assessment.

To determine the validity of the instrument, several procedures were followed. For face validity, the panel of experts assessed the clarity of wording and the whole layout and size of the instrument.

For convergent validity (i.e. the degree to which two instruments that theoretically should be related are, in fact, related (Saris and Gallhofer, 2007)), we used the CDC criteria for wound assessment as there in no “gold standard” for the assessment of surgical wounds. We then compared the percentage of patients identified with an infection according to ASEPSIS to the percentage identified according to CDC criteria. To estimate the difference between the CDC and the ASEPSIS scores the Pearson Chi-square test was applied.

Criterion validity (i.e. predictive validity), the extent to which the ASEPSIS score predicts further outcomes (Saris and Gallhofer, 2007) such as problems in wound healing (e.g. need for therapeutic administration of antibiotics, rehospitalisations), was assessed according to the patients' responses on the telephone interview after the three-month interval. The relationship between the ASEPSIS and the administration of antibiotics, need for rehospitalisation and all the dichotomous variables of from the telephone interview questions was estimated with Chi-square tests.

Finally, the instrument's reliability was estimated for inter-rater reliability (i.e. the percentage of agreement in the ASEPSIS scores between two independent raters, who would simultaneously assess the same orthopaedic surgical wounds). The agreement is considered high if it is above 75% (Gisev et al., 2013). As the ASEPSIS gives a wide range of scores, we considered as an agreement every total ASEPSIS score which would indicate that the patient would fall into the same category relating to wound condition; for example, even if the first rater would give a total score of “11” and the second a total score of “20”, we would consider it as an agreement, as both scores indicate a disturbance of healing, although the rating is obviously different. Intra-rater reliability could not be assessed, as each wound changes over time and therefore the same rater could not repeat the same assessment twice.

Statistical analysis was performed with SPSS 21.0 (IBM Corporation, 2012) and p-values < 0.05 were considered significant.

Results

Descriptive results

In total, 111 patients participated in the study (i.e. 111 orthopaedic surgical wounds) during their hospitalisation and 68 (61.3%) at three months. All of the patients who were contacted agreed to participate in the second part of the study (response rate = 100%). The rest of the patients could not be contacted (e.g., change of telephone number, not answering the phone after 3 attempts), while 3 patients (2.7%) died during the follow-up period (one due to multiple organ dysfunction syndrome, one due to pneumonia, and one due to unknown reason). The mean age of participants was 70.5 years (Standard Deviation- SD 19.5 years) during hospitalisation and 65.95 years (SD 21.14 years) at the three-month follow-up ($p = 0.035$). The sample of participants at three months included statistically significantly more men (38.2% versus 31.5%) and more patients who had undergone total joint arthroplasties (55.9% at three months versus 40.5% during hospitalisation) rather than fractures (44.1% at three months versus 59.5% during hospitalisation) (Table 2).

Validity and reliability

The Greek version of the ASEPSIS was easy and quick to use, as its items were relevant and clear. As the ASEPSIS includes items relating to additional treatment, serous discharge, erythema, purulent exudate, separation of deep tissues, isolation of bacteria, and prolonged hospital stay, it covers most aspects of a surgical wound infection. Therefore, face validity was considered to be very good.

By using the CDC criteria, 5 patients would have been considered as having a superficial incisional wound infection and 2 as having a deep incisional wound infection (i.e. 6.3% had a minor/severe surgical

Table 3
Frequencies of surgical wound infection according to CDC and ASEPSIS criteria.

	During hospitalisation and at 1 month					During 3 months after discharge
	CDC		ASEPSIS		Difference between CDC and ASEPSIS	Telephone interview
	N	%	N	%	p-value	N (%)
No infection	104	93.7	107	96.4	< 0.001, (Phi/ Cramer's V = 0.712)	63 (92.6%)
Infection	7	6.3	4	3.6		5 (7.4%)

wound infection). By using the ASEPSIS, 3.6% of patients would be considered as having a minor/severe surgical wound infection. The difference between the CDC and the ASEPSIS infection rates were because 3 patients were recognised as having surgical wound infection according to the surgeons' diagnosis.

At three months, 92.6% of the participants reported they experienced no problems with wound healing, while 7.4% reported they were given antibiotics for wound infection (Table 3) and 5.4% needed rehospitalisation due to the problems with the healing process during the first month after discharge from the hospital. During the three months after discharge, no participants reported that they needed rehospitalisation (Table 4).

As for predictive validity, ASEPSIS score was related to the therapeutic administration of antibiotics for treatment of wound infection ($p = 0.001$) and the need for rehospitalisation ($p < 0.001$) during the follow-up (Table 4).

The ranges of wound assessment scores were 0–56 points for one rater and 0–48 points for the other. The inter-rater agreement was excellent regarding the agreement for each ASEPSIS score category and up to 90%.

Discussion

There are several definitions for surgical wound infections, the most popular being the definition of the CDC; however, these definitions include subjective measures for wound assessment. The validity and reliability of studies of wound infections are significantly determined by the appropriateness of the instruments used. Therefore, the instruments should be characterized by increased validity and reliability. However, an instrument with high validity and reliability in a specific population does not necessarily have high validity and reliability in a different population. This is the reason why the instruments' validity and reliability should be assessed for every study (Galanis, 2013).

The ASEPSIS is an objective method based on the presence of clinical findings (Hedrick et al., 2015). Furthermore, it is brief and simple to use, so we believe it is the most suitable instrument to use in Greece, not only in the present study, but also on a regular basis. In our previous study, the ASEPSIS had been found easy to use to monitor overall surgical wound infections rates (Copanitsanou et al., 2018c). Our ultimate purpose is to use the ASEPSIS on a regular basis for the surveillance of surgical wound infections in Greek surgical departments. More specifically, the study's objectives were to develop the Greek version of the ASEPSIS, and to evaluate its validity and reliability.

Face validity of the Greek version of ASEPSIS was considered to be very good. As Bruce et al. (2001) reported, in their systematic review; wound discharge, erythema, oedema, pain, tenderness, heat, pyrexia, and wound dehiscence constitute the central components in the 41 different definitions of surgical wound infection. Overall, the instrument was quick and easy to use, so we believe it can be used in everyday clinical practice by both surgeons and nurses. This is very important for Greek surgical departments, as the significant lack of staff (Kondilis et al., 2013) and the increased workload make it difficult to use complicated instruments which need a lot of time to be completed.

According to our findings, 6.3% of patients had a minor/severe surgical wound infection when using the CDC criteria, while the percentage was lower (3.6%) when using the ASEPSIS. This is in accordance with the study of Ashby et al. (2010) in orthopaedic patients, where the infection rate according to CDC criteria was 15.45%, according to the United Kingdom nosocomial infection surveillance was 11.32%, and according to ASEPSIS was 8.79% (which is lower compared to the other definitions for surgical wound infection). However, in the study of Ashby et al. (2010) if the percentage of patients with a disturbance of healing (scores 11–20) was added to that of infection (as a score between 11 and 20 includes some infected wounds), the wound infection rate according to ASEPSIS would be similar to the rate according to CDC criteria; a finding which is not supported by our results, where the difference between the CDC and ASEPSIS assessments is statistically significant. Wilson et al. (1998), comparing the CDC, the ASEPSIS, and Southampton scales, found no significant differences, with the ASEPSIS and Southampton scales being more sensitive than the CDC definition, but not different between each other. In the study of Wilson et al. (2004), wound infection rates were 19.2% according to CDC criteria, 14.6% with the NINSS, 12.3% with the presence of pus alone, and 6.8% with the ASEPSIS (i.e. lower by using the ASEPSIS compared to other definitions).

Although the agreement between definitions with respect to individual wounds seems to be poor overall, the relation of ASEPSIS and CDC has been found to be less consistent in wounds without pus. Hedrick et al. (2015) also reported, in a study of patients after colorectal surgery, higher rates of infection according to the CDC criteria compared to the ASEPSIS. Finally, Chiew and Theis (2007), in a study of surgical wound infection after total hip replacement, found that the infection rates were 4.35% when using clinician diagnosis, 2.61% using the ASEPSIS, and 0.87% using the presence of pus/assessment by a microbiologist.

As for predictive validity, the ASEPSIS score was related to the therapeutic administration of antibiotics and the need for

Table 4
Results in the three month interview by phone *(in italics are the questions included in the ASEPSIS)*.

Questions in the telephone interview	Yes N (%)	No N (%)	Correlation to ASEPSIS score (p-value)
Have the wounds healed without any problems at all?	63 (92.6)	5 (7.4)	< 0.001* (Phi/Cramer's V = 0.557)
Has the wound been red?	4 (5.9)	64 (94.1)	< 0.001* (Phi/Cramer's V = 0.642)
Has the wound discharged clear yellow fluid?	2 (2.9)	66 (97.1)	< 0.001* (Phi/Cramer's V = 0.514)
Has the wound discharged pus?	0 (0)	68 (100)	0.271 (Phi/Cramer's V = 0.240)
Has the wound broken open?	0 (0)	68 (100)	0.019* (Phi/Cramer's V = 0.577)
Have you been given antibiotics for treatment of wound infection?	5 (7.4)	63 (92.6)	0.001* (Phi/Cramer's V = 0.557)
Has the wound needed to be redressed?	4 (5.9)	64 (94.1)	0.001* (Phi/Cramer's V = 0.642)
Has a doctor opened/drained an abscess?	0 (0)	68 (100)	0.008* (Phi/Cramer's V = 0.581)
Have you been admitted to the same hospital?	0 (0)	68 (100)	< 0.001* (Phi/Cramer's V = 0.546)
Have you been admitted to hospital elsewhere?	0 (0)	68 (100)	< 0.001* (Phi/Cramer's V = 0.581)
Has the wound been opened and cleaned under general anaesthetic in hospital?	0 (0)	68 (100)	< 0.001* (Phi/Cramer's V = 0.514)

*Statistically significant ($p < 0.05$).

rehospitalisation during the three-month follow-up. However, the correlations between the ASEPSIS scores and the participants' responses to the telephone interview should be interpreted carefully, as the assessments with the ASEPSIS were performed during hospitalisation and the first month after discharge, a period included in the three-month follow-up period.

In a review of studies in which the ASEPSIS was used for the assessment of surgical wounds after non-cardiac surgical operations, it was found that its validity and reliability could not be established, with its reliability declining as the severity of infection worsened (Siah and Childs, 2012). However, as it has already been argued, an instrument for daily use in clinical settings should primarily be practical and straightforward and does not need to be as sensitive in the detection of minor infections as that needed for epidemiological research (Bruce et al., 2001). Although validity and reliability were satisfactory in the present study, the Greek version of ASEPSIS should also be used with caution until more research studies are conducted. Future research should include larger sample sizes and patients undergoing different types of surgical operations. Such studies would help to conclude whether the ASEPSIS is an appropriate instrument for the assessment of all surgical wounds.

The inter-rater agreement was excellent; up to 90% in this study. In another research study, ASEPSIS assessments demonstrated excellent inter-rater agreement between surgeons, with the agreement reaching 96% (Hedrick et al., 2015). The inter-rater reliability was also high in the study of Wilson et al. (1998), in patients who had undergone general surgeries and cardiac surgeries.

Prevention of surgical wound infection is an important responsibility for nurses. However, their knowledge on prevention guidelines may be inadequate (Labeau et al., 2010; Moran and Byrne, 2018), including the knowledge about signs and symptoms of infection (Moran and Byrne, 2018). In the literature there is little discussion about how the clinical characteristics of surgical wounds should be assessed by nurses, the frequency of these assessments and to what extent the findings are documented (Ding et al., 2016). It has been postulated that nursing wound care practices may be enhanced by developing nurses' role, professional status, and self-regulation, among others, providing nurses with more autonomy (Timmins et al., 2018). The use of ASEPSIS may empower nurses to assess orthopaedic surgical wounds autonomously, as it is quick and easy to use and assessment by a surgeon or other physician is unnecessary, as is the case with the CDC criteria. This may be more important to nurses with less experience, who may not feel comfortable in assessing surgical wounds. In addition to this, as nurses are the healthcare professionals who remain at the patients' bedside and provide care for the full 24 h period, it can be argued that their use of a validated tool such as the ASEPSIS may mean the timely identification of a surgical wound infection, to allow for earlier interventions and treatment. This may ultimately lead to shorter hospitalisation, reduction of the burden for the patient and the family, and lower resource use for the healthcare system. Finally, a similar methodology for the translation and validation of the ASEPSIS into other languages could be applied by nurses in other countries.

As there is no “gold-standard” instrument for the assessment of surgical wounds, the comparison of ASEPSIS to CDC criteria for determining convergent validity may represent a limitation of this study. Also, participants at three months after discharge were significantly younger and had undergone more arthroplasties (i.e. elective surgeries) rather than fractures (i.e. emergency surgeries). This was an expected finding, as patients with fragility fractures present higher institutionalisation rates and mortality (Friedman and Mendelson, 2014; Ouanes et al., 2014) and therefore are harder to follow after discharge. However, this means that the two samples are not similar and this represents a possible bias; as participants in the follow-up tended to be younger, healthier and having undergone more elective procedures, the incidence of infections may have been underestimated. Since we were not able to contact these more frail patients, we cannot know whether these patients needed rehospitalisation for a surgical wound infection. As primary care remains underdeveloped in Greece (European Commission, 2016), many patients are not followed after discharge from the hospital and we could not communicate with a general practitioner about their status. Finally, although the method of telephone interview has been proven to have high sensitivity and specificity (Health Protection Scotland, 2010), the participants may not have been educated adequately to understand and recognise what is meant by each question exactly, e.g. some patients may have thought discharge of lymph as discharge of pus. This might have led to an overestimation of infections.

To our knowledge, this is the first study to validate the ASEPSIS tool in Greek, an instrument which could be incorporated both into clinical nursing practice as well as in nursing research. This would allow implementation of specific and timely interventions with the aim of reducing surgical wound infections and comparison of surgical wound infection rates both in the same surgical department in the future, as well as in national studies.

Conclusions

Validity and reliability of the Greek version of the ASEPSIS were satisfactory in the present study. Overall, the ASEPSIS is an objective, brief and simple instrument, for use by both surgeons and nurses. We believe it is the most suitable method for the assessment of surgical wounds in Greece, not only in the present study, but also on a regular basis and in research. However, before it could be used on a larger scale, more studies should be conducted in patients having different surgeries.

Author contributions

PC, VAK, TBG and PW were responsible for the study conception and design. PC and VAK performed the data collection and PC was responsible for the drafting of the manuscript. Translation of the instrument and obtaining permission from the original authors and ethical permissions for the data collection in the hospital was performed by PC and VAK. Cultural adaptation was made by TBG. PC and PG performed the data analysis. All authors have made their critical revisions and approved the final version of the manuscript.

Ethics in publishing

The study was approved by the hospital's Institutional Review Board (11193/17-09-2014, date of approval 31-10-2014). The principles of the Declaration of Helsinki were applied throughout the study. An informed consent was obtained from all participants. All patient data were coded and only the researchers had access to them.

Conflicts of interest

No conflict of interest is declared by the authors.

Role of the funding source

No funding was received for this study.

Appendix A. Supplementary data

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